ROENTGENOGRAPHIC OBSERVATIONS OF THE TIMES OF APPEARANCE OF EPIPHYSES AND THEIR FUSION WITH THE DIAPHYSES[1]

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A perusal of the various anatomical authorities shows considerable discrepancy regarding the ages at which the various epiphyses appear and fuse with their respective diaphyses. In former years, the only method of examination of epiphyses was to study the dead subject, but opportunities of doing this on an extensive scale are very rare, and in any case it is not always a simple process to determine from dried skeletons whether an epiphysis has been present or not. Moreover, with the exception of a study by Stevenson on a rather limited number of dried skeletons, no such attempt appears to have been made. However, it is by means of a roentgenographic examination that not only are the epiphyses more clearly and more certainly demonstrable in most cases in the living subject, but a larger series, with exact information concerning the respective ages, can be more easily studied and compared.

It has been felt that a much more accurate and authoritative account of the dates of appearance and fusion of epiphyses than is at present available would be of very great value for comparative purposes, especially in investigations concerning racial differences, effect of environment and climate, and for clinical and medico-legal purposes. It is hoped that this may stimulate further research in various directions, and such research will have a value in direct proportion to the accuracy with which the observations are recorded. The author can nowhere find accurate statistics actually based on the number of subjects examined with the exceptions of Galstaun, Sidhom and Derry and Pryor.

Galstaun presented the results of investigation of about 100 Hindu and Anglo-Indian girls aged 13 to 19 years, the work being limited to the regions of the elbow, wrist and hand. His figures have been made use of for the purpose of comparison, but these show no very gross disparity with the series presented here.

Sidhom and Derry investigated the union of some of the epiphyses of the upper limb in over 400 Egyptian boys, mostly between the ages of 14 and 20, being like Pryor particularly accurate in recording the ages. The boys were specially examined for the purpose of their research. As compared with the

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boys in the Australian series, the majority were fused at the same age in the cases of the medial epicondyle and both extremities of the radius, a year earlier for the lower conjoint epiphysis of the humerus, distal epiphysis of the ulna and for the first metacarpal, and two years earlier for the distal phalanx of the thumb. With regard to the extremes, there were instances of both earlier and later fusions in the Egyptian series.

The work of Pryor, however, is of monumental importance, for, as the result of a study of 554 roentgenographs of the hands of children from 3 months to 14 years of age, he came to the following conclusion: "The bones of the female ossify in advance of the male. This is measured at first by days, then months, then years," a conclusion which is abundantly confirmed elsewhere. Moreover, he has carried his research further and studied the roentgenographs of 140 foetuses from 10½ to 38 weeks of age, 71 being male and 69 female, and reached the very unexpected result that "in the ossification of the human skeleton, the female is in advance of the male from the earliest developments of centres of ossification in the embryo and throughout intrauterine life, progressing from days to weeks and months." Such advance apparently takes place even before external sex differentiation can be determined.

Although abundant evidence of the advance in females is present from the period about birth, Pryor does not give any data regarding such priority from the "earliest developments of centres of ossification."

Stevenson studied the periods of fusion only in 110 skeletons aged between 15 and 28, including 83 from 15 to 25 years of age. He makes the following extraordinary criticism of the X-ray examination, which is quite unjustified: "The recent assertion by Pryor, made without any confirmatory evidence, that the epiphyses in the female unite 3 to 4 years earlier than in the male receive no support in this work. On the contrary, the reader is warned against relying too confidently upon the apparent condition of union or of non-union in the radiogram which is merely a confusing medley of shadows."

However, as Stevenson has not separated the skeletons of the females from the males, they are not of value for the purpose of comparison with the Australian series, and in any case, of the 110 subjects between 15 and 28, but 20 are female, of whom 18 are between the ages of 15 and 25. Many of the conclusions arrived at can readily be challenged, particularly the alleged constancy of behaviour of the epiphyses with regard to the ages of fusion.

Borovansky and Hnevkovsky investigated the bones of both the upper and lower extremities of 352 boys of all ages up to 19 years, the roentgenographs being specially made for the purpose of the research. Even with this limited material, all of boys from Prague, charts representing the periods of ossification are shown, although the actual number at each age is not given. The work, however, is valuable, inasmuch as many measurements of the size of the various epiphyses at different ages are given.

Recently Paterson has investigated about 1000 films and roughly tabulated his results, although he gives no actual statistical figures.

Davies and Parsons have described the appearances of epiphyses as seen in roentgenographs, giving detailed information of the ages when these were seen, but no numerical data from which the relative frequency can be ascertained are given. Unfortunately, the sexes of the individual examples are more frequently omitted than inserted in the text.

The subjects of this examination were mostly hospital patients, practically all of whom are of European descent, and as nutritional diseases, such as rickets, scurvy, etc., are rarely met with in Australia, the error from including such possible conditions is practically insignificant. To avoid duplicating details of the same subjects, and to assist in checking off age and sex particulars, the names of the individuals and serial numbers of the films were also recorded. Notes were made only of such epiphyses whose presence or absence could be definitely established. All others are excluded from the records.

The ideal method of presenting the results of such an enquiry would be by means of graphs, but the material available is not nearly sufficient for the purpose, although Stevenson prepared graphs for a very much smaller series. To give percentages, even roughly, where in no instance are there 100 subjects in any age group is likewise objectionable, although other authors, notably Paterson, have done so. Many such percentage computations must be sheer guess-work, and appear to have been made even when less than a dozen subjects were in question. The only honest, and, it is thought, the best method is to give the actual figures in each age group, and this has been done.

Stevenson and Paterson have both summarised in considerable detail the ages of appearance and fusion of the different epiphyses as given by numerous authors. Although this is very useful as serving to demonstrate the various discrepancies, a repetition of such lists here would serve no useful purpose, and it would be better to discard all data except those based on actual statistics.

With regard to the various descriptions which follow, the following points were specially noted with reference to each sex:

(*a*) Youngest subject where epiphyses in question were found to be present.

(*b*) Ages at which the majority of the epiphyses in question were present.

(*c*) Oldest subject in whom epiphyses had not yet appeared.

(*d*) Youngest subject where epiphyses were found to be fused with the diaphyses.

(*e*) Ages at which the majority of the epiphyses were found fused.

(*f*) Oldest subject in whom epiphyses had not yet fused.

Though classifications have been made regarding the sex, and notes have likewise been taken with respect to the sides, whether right or left, any classification regarding the side would considerably burden this article, but as yet, no detailed study has been made concerning the possibility of any appreciable difference of one side as compared with the other. Moreover, it is doubtful whether such a difference exists, although in right-handed individuals it is quite conceivable that the different function of one side as compared with the other might lead to some variation of the times of appearance of epiphyses.

It has been noticed repeatedly that an epiphyseal centre is present on one side although absent on the other in the corresponding bone of the same individual. Of 25 such examples in different bones, the epiphyses were noted 16 times to be present on the right side but not on the left, whilst in the other 9 they were present on the left but not on the right.

Koehler has stated that the order of appearance of epiphyses is not necessarily the same on both sides, even in the same individual, as may be noted in the example of the carpal bones of a child given later (see fig. 2). This does not accord with Pryor's observations, "Regardless of the variations (normal) the ossification is bilaterally symmetrical." Nor are they necessarily the same in twins, as shown by Borovansky and Hnevkovsky, who figure the hands of twin boys aged 6, where in one boy the navicular was present on one side but not on the other, and was absent on both sides in the brother. In the first boy the multangulum minus was present on both sides, but absent on both sides in the brother.

With regard to the time of fusion, that this process usually occupies only a few months seems to be indicated by an observation of the epiphyseal plate between the tip of the olecranon process and the diaphysis of the ulna in a subject aged 15 which showed as a considerable gap on the roentgenograph at 16 December, but at 29 May next not the slightest trace of the epiphyseal line could be detected. The author believes that Galstaun's classification into "commencing union," "earlier stage of same process," "nearly complete union" and "union just complete" is superfluous and unnecessarily complicates the observations. The author has merely noted non-fusion or fusion, the latter referring to entire disappearance of the epiphyseal plate, which is in most cases not difficult to determine. A linear shadow which may sometimes persist even for years at the junction of epiphysis and diaphysis is interpreted as fusion. When comparing Galstaun's records, his classification "union just complete" is included with fusion, the others as non-fusion. Stevenson, as well as Sidhom and Derry, have likewise described several stages of fusion.

The study of primary centres and epiphyses during intra-uterine life has been dealt with in another article.

THE CLAVICLE

The medial extremity of the clavicle was noted in 655 instances under the age of 30. The youngest female in whom an epiphysis was noted was aged 11, where it was present on the right side but absent on the left, and the youngest male 12, the oldest being 25 years of age in a male and 26 years and 11 months in a female in whom it was present on the left but absent on the right, in each case being present on both sides. The centres are infrequently seen under 17 or over 22 years of age. Stevenson states that it may be delayed until 28 years, but of 33 subjects aged 27 to 29, no epiphyses were seen. At no age do more than 64 per cent. of clavicles appear to be possessed with epiphyses, suggesting the possibility that the epiphyseal centre for this bone is not a

constant feature, but it must be remembered that such centres are frequently very difficult to demonstrate, partly owing to the irregularity of the sternal end of the clavicle, as well as to a mixed background of intrathoracic structures, vertebrae and posterior parts of ribs, whilst confusion with costo-transverse and costo-central articulations must be particularly avoided.

Age	No. of instances in girls	No. of instances in boys	No. of centres in girls	No. of centres in boys
11	12	2	1	0
12	11	9	0	1
13	3	15	0	0
14	8	10	2	2
15	10	11	2	1
16	16	14	4	1
17	12	12	5	5
18	10	15	2	3
19	25	11	11	7
20	28	19	12	7
21	14	20	7	11
22	18	11	5	4
23	17	16	4	4
24	18	15	4	1
25	19	18	2	2
26	10	8	1	0

From the above table it appears that the majority of young people of both sexes aged 21 possess epiphyses for the sternal end of the clavicle, but at all other ages the majority show absence of epiphyses. This suggests that in the majority of instances the centre appears at the age of 21 in both sexes, and that fusion takes place in the majority of instances at the age of 22 in each sex.

INFERIOR ANGLE OF THE SCAPULA

The epiphysis for the inferior angle of the scapula was clearly demonstrated in one subject only, a female aged 17, where the scapulae were thrown clear of the bony chest, and where it was present on both sides. This centre is evidently but rarely seen, probably because the angle of the scapula is usually much obscured by the background formed by the various structures of the chest.

CORACOID PROCESS

The cartilaginous junction of the coracoid process with the body of the scapula was specially noted in three girls between the ages of $4\frac{1}{2}$ and $7\frac{1}{2}$ inclusive, when the arm was elevated above the horizontal. It was likewise seen in a boy aged 10 years and 3 months. Regular observations, however, of this process are rendered difficult by the overshadowing of the coracoid by the spine of the scapula as well as by the clavicle and head of the humerus in the ordinary position of the shoulder with the arm adducted to the side, so that detailed classification could not be attempted.

EPIPHYSIS AT ANGLE OF CORACOID PROCESS

This epiphysis is usually present at the junction of the ascending and horizontal rami on the medial aspect, where it forms a thin scale of bone (see fig. 1).

The youngest instance where this was noted was a girl aged 10 years and

2 months, where it was present on the right side but absent on the left. This was the only epiphysis out of 54 instances in both sexes aged 10 to 12, but examples were noted in a girl aged 13 years and 10 months on both sides and in a boy at the age of 14. Of 240 instances (including 124 males and 110 females) aged 13 to 19 there were only 7 (6·36 per cent.) in the female although there were 23 (18·54 per cent.) in the male, suggesting a probability of greater frequency in the latter. In any case the rarity of these centres makes

Age	No. of instances in girls	No. of instances in boys	No. of centres in girls	No. of centres in boys
13	6	18	2	0
14	10	16	1	2
15	6	13	1	2
16	23	14	2	5
17	25	14	1	5
18	9	25	0	8
19	31	24	0	1

it reasonably certain that this epiphysis is not a constant feature in the human subject. It would appear that in the female the appearance as well as the fusion with the ramus is earlier than in the male; thus of 40 females aged 18 and 19, no epiphysis was seen, although 9 such were present in 49 males of the same age. The epiphysis was most frequently found in males at the age of 16 and 17. The oldest female with unfused epiphysis was aged 16, where it was present on both sides, and the oldest male 19.

TIP OF CORACOID PROCESS

In boys aged 14 years and 7 months and 15 years and 6 months respectively (see fig. 1) not only were the usual centres present for the acromion and for the angle of the coracoid, but there were additional centres for the tip of the coracoid. In another boy aged 16 a similar centre for the tip of the coracoid was present as well as additional centres for the acromion process, although that for the angle of the coracoid was absent.

THE ACROMIAL EPIPHYSIS

The centre for the distal extremity of the acromion process sometimes consists of two or more fragments and is often seen in the same roentgenograph showing the presence of the epiphysis for the angle of the coracoid (see fig. 1). For clear demonstration, the roentgenograph should not be over-exposed:

Age	No. of instances in girls	No. of instances in boys	No. of centres in girls	No. of centres in boys
13	6	7	2	0
14	4	10	4	4
15	4	9	2	5
16	7	10	4	8
17	9	5	0	2
18	6	14	0	6
19	10	19	0	2

very many views of the shoulder joint, even when clearly defining the various details of the joint itself, had to be discarded because of obliteration of detail of the acromion process resulting in a much smaller series than in the case of the coracoid process for instance.

The earliest appearances were in a girl on each side at the age of 13 years and 10 months, and in a boy at the age of 14 years and 11 months. It was present in the majority of females at the age of 14 and of males at the age of 15 years, and was fused in all instances in females at the age of 17 and in the majority of the males at the age of 17. Whilst the oldest female with an epiphysis was aged 16 years and 1 month, the oldest male was 19 years and 2 months.

Again, it is by no means certain that a centre always appears at the distal end of the acromion, for in 126 instances aged 13 to 19 (including 74 males and 46 females) there were but 41 (32·5 per cent.) epiphyses (inclusive of 27 males and 11 females) noted.

EPIPHYSIS FOR HEAD OF HUMERUS

At birth, the upper end of the humerus in the antero-posterior view appears to present two inclined planes meeting at a point in the centre. Over the medial of these inclined planes, the centre for the head of the bone makes its appearance during the first year after birth.

Of 25 instances in babes during their first year, the oldest without epiphyseal centre was a boy aged 6 months. The earliest centres noted were 4 months in the male and 5 months in the female. Davies and Parsons have seen it present in 2 of 4 subjects at birth. These are all earlier than any of the ages usually quoted.

Although Spencer was able to find by dissection in 40 foetuses weighing 7 lb. or more only nine instances of centres (22 per cent.) for the head of humerus, the author found this centre present in 6 of 10 foetuses over 294 mm. in length (including a female of 294 mm. and a male of 295 mm.).

GREATER TUBERCLE OF THE HUMERUS

Many radiologists, notably Cohn, doubt the existence of a separate centre of ossification for the greater tubercle, and are of opinion that this process is developed from extension of the centre for the head over the lateral aspect of the upper end of the diaphysis, but in numerous instances in young children, each centre has been noted side by side, one for the head lying on the inclined plane on the medial aspect and the other on the inclined plane on the lateral side. Unfortunately, in very many instances, the head of the humerus is obscured by the overhanging acromion process or even by the coracoid, so that it is frequently difficult to define the centre for the greater tubercle and to separate it from that for the head proper. Borovansky and Hnevkovsky give very good diagrams illustrating the appearances of the head and greater tubercle in the boys of Prague of various ages from 4 years and 1 month to 14 years and 7 months.

However, during the first year after birth, the earliest epiphysis for the greater tubercle was noted at 9 months (sex unknown), and 11 months in both sexes. Davies and Parsons report its presence in an infant aged 8 months. Its

absence was also noted at 11 months in a female and 3 years and 6 months in a male (both sides), while it was present in all five instances in females aged

Age	No. of instances in girls	No. of instances in boys	No. of centres in girls	No. of centres in boys
Under 1	3	7	2	1
Over 1	1	14	1	3
2	5	4	5	2
3	8	6	6	4
4	7	5	3	4
5	7	7	2	1
6	13	4	3	2
7	7	7	0	0
8	1	7	0	0
9	3	9	0	1

2 years. Paterson reports the appearance of this centre at the end of the second or beginning of the third year, practically a year later than the author's observations seem to show. All other anatomists give 2 to 3 years.

FUSION OF CENTRES FOR GREATER TUBERCLE AND HEAD OF HUMERUS

After the first two years or earlier, the centre for the tubercle overlaps that for the head of the bone, the two fusing together, the line of union forming the anatomical neck (see fig. 1). The plane of fusion is very oblique and in very many instances, from the appearance of the roentgenograph even by stereoscopic examination, it is impossible to be certain whether fusion has occurred or not. From the above table it will be noted that fusion had taken place in half of the instances in girls at the age of 4 and in the majority of boys at the age of 5, although isolated instances of non-fusion were noted in a girl aged 6 (both sides) and in a boy aged 9. Davies and Parsons found non-fusion at the age of 12 in one instance.

LESSER TUBERCLE OF HUMERUS

Like other radiologists, the author has failed to find a specimen showing the presence of this centre and accordingly must doubt its existence. However, the position of the lesser tubercle in front of the bone would certainly make such a centre, if it were present, much more difficult to demonstrate, especially as it is usually impossible to secure a good lateral view of this part of the limb. Practically all anatomists describe its presence.

FUSION OF THE UPPER CONJOINT EPIPHYSIS WITH THE DIAPHYSIS OF THE HUMERUS

Age	No. of instances in girls	No. of instances in boys	No. fused in girls	No. of centres fused in boys
16	8	15	3	1
17	16	10	15	2
18	7	12	6	4
19	20	19	20	16

From the above figures it seems that the age of fusion of the combined epiphysis for the head and greater tubercle with the diaphysis seems fairly constant. The earliest fusion was at the age of 16 years and 8 months on both sides in a female, and 16 in a boy, the latest 18 in a female and 19 years and 2 months in the male. In none of 20 subjects aged 15 (16 boys and 4 girls) were these epiphyses fused, nor were any epiphyses noted in 30 others (including 14 males and 11 females) aged 20. The majority were fused at the age of 17 in females and 19 in males. Union was constantly found at 19 in females and 20 in males, which does not at all correspond to the various ages, 20 to 25 given by numerous anatomists, and they differ from those given by Paterson, namely 18 for females and 21 for males.

EPIPHYSIS FOR THE LATERAL EPICONDYLE

Age	No. of instances in girls	No. of instances in boys	No. of centres in girls	No. of centres in boys
9	6	11	2	0
10	6	18	2	3
11	6	10	5	3
12	1	23	1	15
13	5	15	2	12
14	4	14	1	10
15	7	12	0	8
16	6	10	2	1

From the above table it can be noted that the earliest centres observed for this epiphysis were in a girl aged 9 (both sides) and a boy aged 10 years and 7 months. At the age of 11 in females and 12 in males, this epiphysis was found present in the majority of instances, whilst the oldest subjects with unfused epiphyses were aged 16 in each sex (both sides in a female). Despite the opinions of Cohn and Paterson, this epiphysis is probably present, like those of the capitulum, trochlea and medial epicondyle in every case at some period between 8 and 17 years. It was present in 37 of 52 males (71 per cent.) aged 12 to 14 and 22 of 29 males (75 per cent.) aged 13 and 14. The case figured by Paterson, which is described as an extension of the capitular epiphysis and which is stated to occur in 30 per cent. of cases, is certainly a fusion of the capitulum with the lateral epicondyle, which always takes place before union of the conjoint epiphysis with the diaphysis.

CAPITULUM

With the exception of male infants aged 1 week and 1 and 6 months respectively, where the capitulum was not present in any case, no babe under the age of 9 months was examined. The centre was present in the female child of 9 months on both sides and in a male aged 11 months, as well as in all older children. The author has found the capitulum present in every one of 21 instances at the age of 1 year, in all of 28 aged 2 and 20 aged 3. Davies and Parsons report its absence in one instance at 18 months.

THE TROCHLEAR EPIPHYSIS

Age	No. of instances in girls	No. of instances in boys	No. of centres in girls	No. of centres in boys
8	12	16	4	3
9	6	11	5	2
10	7	17	5	9
11	6	11	5	8
12	2	23	2	21
13	5	16	2	13
14	4	17	1	14
15	7	14	0	11
16	4	9	2	1

The earliest centres for the trochlea were noted at the age of 8 years and 5 months (both sides) in a girl and 8 years and 9 months (both sides) in a boy, whilst the majority of girls aged 9 and of boys aged 10 showed the presence of this centre. The epiphyses were still evident in a girl aged 16 on both sides as well as in a boy of the same age.

UNION OF EPIPHYSES OF LATERAL EPICONDYLE, CAPITULUM AND TROCHLEA

Many anatomical authorities describe the union of the epiphyses of the lateral epicondyle and trochlea on each side of the capitulum forming a new conjoint epiphysis which fuses at a later date with the diaphysis. From a roentgenological point of view this appears to be correct, and there is no valid reason for the supposition as suggested by Paterson, that in some 30 per cent. of cases the lateral epicondyle is formed by extension from the capitulum. If this were the case, one would expect to find intermediate stages

	Lateral epicondyle, capitular and trochlear epiphyses present		No. fused with each other	
Age	Girls	Boys	Girls	Boys
8	1	0	0	0
9	2	0	0	0
10	1	2	1	0
11	5	3	1	0
12	1	15	0	2
13	2	11	1	4
14	1	9	0	7
15	0	9	0	5
16	2	1	0	1

of this extension, such as may be observed in the case of the spinous process developed from the primary centre of the scapula, or the main part of the olecranon process from the shaft of the ulna, but such intermediate stages are not seen. On the contrary, the adjacent margins of the epiphyses for the lateral epicondyle and capitulum prior to fusion are always smooth and well defined.

The union of the lateral epicondyle and trochlea on each side of the capitulum is almost simultaneous, although the former is sometimes slightly

later than the latter. The lateral edge of the trochlea is generally narrow and often ill defined, in marked contrast to the smooth surfaces of the capitulum and lateral epicondyle. In fact, the latter is somewhat discoidal in shape and sometimes appears to belong to the capitulum rather than to the shaft of the bone.

In a girl aged 10 the three epiphyses were fused with each other, but the earliest instance in a boy, where they were fused on both sides, was at the age of 12. Union had taken place in half of the boys at the age of 13, but had not occurred on either side in a girl aged 16 nor on either side in a boy aged 15.

As Galstaun, unfortunately, had failed to note the union of the epiphyses of the capitulum to the lateral epicondyle and trochlea on each side prior to the union of the conjoint epiphysis to the shaft, his observations regarding these epiphyses will not be applicable for the purposes of comparison.

FUSION OF COMMON DISTAL EPIPHYSIS WITH DIAPHYSIS OF HUMERUS

		Instances in boys			Fusion in boys	
Age	Instances in girls	Author	Sidhom and Derry	Fusion in girls	Author	Sidhom and Derry
13	5	18	—	3	0	—
14	4	18	91	3	2	32
15	7	15	43	7	4	33
16	6	10	95	5	9	88

The earliest age at which union occurred was 13 years and 4 months in a girl and 14 years and 7 months in a boy. The majority showed fusion at the age of 13 in girls and 16 in boys, but instances of non-fusion were noted at the age of 16 in both sexes (on both sides in a female). Sidhom and Derry found the majority amongst Egyptian boys fused at the age of 15, that is a year earlier than in the Australian series.

EPIPHYSIS FOR THE MEDIAL EPICONDYLE

The medial epicondyle, unlike the lateral, is quite separate from the other centres at the lower end of the humerus and fuses directly and independently with the diaphysis.

The earliest age this has been noted is 3 years and 10 months in a female and 5 years and 9 months in the male. None of 23 boys aged 3 and 4 showed this epiphysis, although of 7 girls at these ages there were 3 examples. The centre was found in most girls at the age of 5 and in most boys at 6 years of age. Its absence was noted in a girl aged 6 and a boy aged 7.

The youngest girls where the medial epicondyle was found fused with the diaphysis were aged 10, the youngest boys 12, in one case being present on the right although fused on the left side. In one half of the girls union had taken place at the age of 14 and in one half of the boys at 16. An instance of

non-fusion was noted in a girl aged 16 (both sides) and in a boy aged 17 years and 0 months. Paterson gives the date of union as 18 to 21 in males, but in this series, in every one of 29 instances in males at these ages, it was already fused. Sidhom and Derry found amongst Egyptian boys that the majority had fused at the age of 16, that is about the same as in the Australian series,

	Instances in girls		Instances in boys		Centres in girls		Centres in boys	
Age	Author	Galstaun	Author	Sidhom and Derry	Author	Galstaun	Author	Sidhom and Derry
3	4	—	9	—	2	—	0	—
4	3	—	14	—	1	—	0	—
5	17	—	12	—	16	—	5	—
6	8	—	8	—	7	—	5	—
7	8	—	15	—	8	—	14	—
10	7	—	18	—	4	—	18	—
11	3	—	12	—	3	—	12	—
12	1	—	21	—	1	—	19	—
13	5	7	15	—	3	0	14	—
14	3	24	15	101	2	6	14	95
15	7	16	16	39	0	1	16	29
16	6	12	10	98	3	2	5	41
17	5	16	16	95	0	0	7	15
18	5	9	10	68	0	0	0	6
19	4	3	8	24	0	0	0	1

but in one Egyptian boy union had not taken place at the age of 19 years and 3 months.

According to the results of Galstaun, it would appear that fusion does not take place earlier in Hindu than in Australian girls. Unfortunately, the Australian series is scarcely large enough for a true comparison.

EPIPHYSIS FOR THE TIP OF THE OLECRANON PROCESS

The main part of the olecranon process is formed by an extension upward from the diaphysis, a small wedge including the tip alone being formed from a separate centre, which may or may not comprise part of the articular surface of the greater semilunar notch. Generally there is only one centre, but often there are two or more.

	Instances in girls			Centres in girls		
Age	Author	Galstaun	Instances in boys	Author	Galstaun	Centres in boys
6	9	—	15	1	—	0
7	9	—	16	0	—	1
8	12	—	19	7	—	3
9	4	—	11	4	—	3
10	7	—	18	3	—	15
11	5	—	12	5	—	8
12	2	—	27	2	—	26
13	4	7	15	3	7	14
14	4	24	18	1	14	17
15	8	16	18	0	2	16
16	5	12	5	3	0	2

The youngest subjects where epiphyses were present were a girl aged 6 and a boy aged 7. From the above it would appear that the epiphysis is present in a majority of girls at the age of 8 and of boys at the age of 10. Whilst fusion

takes place in the majority of girls at the age of 14, union does not occur in the majority of boys until 16 years of age. Instances of non-fusion were noted in a female at the age of 16 years and 0 months and in a male at 17 years and 6 months. The epiphyses had not yet appeared on either side in girls aged 10, but examples of absence, whether non-appearance or of fusion, can be noted at all ages in boys. The earliest to fuse was a girl aged 13. Absence of epiphyses may be noted at all ages in boys.

The much smaller Australian series suggests earlier fusion than is the case in Indian girls.

PROXIMAL EPIPHYSIS OF THE RADIUS

	Instances in girls		Instances in boys		Centres in girls		Centres in boys	
Age	Author	Galstaun	Author	Sidhom and Derry	Author	Galstaun	Author	Sidhom and Derry
3	7	—	14	—	2	—	0	—
4	6	—	16	—	3	—	7	—
5	19	—	14	—	11	—	9	—
6	9	—	16	—	7	—	11	—
7	10	—	20	—	10	—	19	—
8	19	—	23	—	19	—	22	—
13	7	7	17	—	5	7	17	—
14	9	24	20	99	4	7	19	91
15	7	16	19	41	1	3	18	28
16	7	12	11	98	2	1	5	35
17	3	16	20	94	0	2	9	11
18	5	9	10	67	0	1	0	5

The earliest epiphysis noted was in a girl aged 3 years and 4 months and in a boy aged 4 years and 3 months. Davies and Parsons noted an instance in a girl aged 2. The majority of both sexes aged 5 showed the presence of this epiphysis. It was absent in girls aged 6 and in a boy aged 8.

The earliest age at which fusion had occurred was 13 in girls and 14 in a boy. Union had occurred in the majority of females at the age of 14 and of males at 16. One girl aged 16 showed non-fusion on both sides, whilst non-fusion on both sides was also noted in a boy aged 17 years and 6 months. Davies and Parsons found non-fusion in one subject at the age of 19 years.

Sidhom and Derry found the epiphysis of the majority of Egyptian boys fused at the age of 16 as above. In one instance it was not fused at the age of 18 years and 6 months.

Whilst in the Australian series were two instances in girls where fusion had occurred at the age of 13, in some Hindu girls this had not taken place at a later period than any of those of the Australians, in one instance at the age of 18.

In no case has a separate centre for the tubercle of the radius as described by Frazer been found.

DISTAL EPIPHYSIS OF RADIUS

The youngest female in whom this centre was seen was aged 10 months, where it was present on both sides, but it was not seen in any of 4 boys in their first year. One boy 1 year and 7 months old likewise showed no centre,

although present in 3 other boys in their second year. Cohn states that this epiphysis is constantly present at the age of 6 months, yet in 3 males, aged 10 months, 11 months and 1 year respectively, this was not the case. The centre was found in every one of eight instances in girls in their second year and in all of 19 instances of both sexes aged 2.

The youngest female in whom fusion had occurred was aged 16 years and 6 months, the youngest male 18 years and 5 months. The majority of females aged 18 and of males aged 19 showed union with the shafts. The oldest subjects

	Instances in females			Instances in males		
Age	Author	Pryor	Galstaun	Author	Pryor	Sidhom and Derry
Under 1	2	—	—	4	—	—
1	8	—	—	4	—	—
14	7	14	24	44	2	104
15	5	6	16	42	3	41
16	13	12	12	42	4	99
17	12	17	16	37	14	90
18	14	7	9	36	12	70
19	4	10	3	30	8	23
20	7	6	—	17	6	—
21	5	1	—	27	2	—
22	7	2	—	20	5	—
23	9	—	—	19	—	—

	Centres in females			Centres in males		
Age	Author	Pryor	Galstaun	Author	Pryor	Sidhom and Derry
Under 1	2	—	—	0	—	—
1	8	—	—	3	—	—
14	7	14	22	44	2	104
15	5	6	12	42	3	41
16	9	12	8	42	4	91
17	7	11	11	37	13	74
18	3	4	5	29	12	36
19	1	4	1	11	6	7
20	0	0	—	6	1	—
21	0	0	—	4	0	—
22	0	0	—	0	0	—
23	0	—	—	1	—	—

in whom union was not complete were a female aged 20 years and 5 months and a male aged 23.

Although there were six instances amongst 40 Hindu girls aged 14 and 15 in whom the centre had fused earlier than in any of the Australian series, only 15 out of 40 Hindu girls showed fusion between them of ages 16 and 19 compared with 23 out of 42 of the author's series. Although the majority of the Australian girls showed fusion at the age of 18, this was not the case amongst the Hindu girls until at least 19 years of age.

Sidhom and Derry found the majority of epiphyses in Egyptian boys united at the age of 19 as in the Australian series. In some instances union had occurred at the age of 16.

Like Galstaun, Pryor found union in American females at 19 and males at 20, that is later than in both the Australian and Egyptian series.

DISTAL EPIPHYSIS OF ULNA

The centre for this epiphysis was first seen at the age of 5 in each sex. Paterson reports it present in a girl aged 4. The epiphysis was present in the majority of girls at the age of 5 and boys at 6 years of age. The oldest girl in whom it was found absent was aged 7, and the oldest boy 8, except for an isolated instance in a boy aged 12.

The youngest female where this centre had fused was aged 16 years and 6 months, the youngest male 18 years and 5 months. It will be noted that

	Instances in females			Instances in males		
Age	Author	Pryor	Galstaun	Author	Pryor	Sidhom and Derry
5	3	—	—	7	—	—
6	7	—	—	11	—	—
7	6	—	—	23	—	—
8	11	—	—	12	—	—
13	10	2	—	35	3	—
14	7	14	24	44	2	104
15	5	6	16	42	3	41
16	12	12	12	41	4	94
17	11	17	16	33	14	87
18	14	7	9	34	12	69
19	4	10	3	29	8	24
20	8	6	—	16	6	—
21	5	1	—	27	2	—
22	8	2	—	20	5	—
23	19	—	—	17	—	—

	Centres in females			Centres in males		
Age	Author	Pryor	Galstaun	Author	Pryor	Sidhom and Derry
5	2	—	—	2	—	—
6	4	—	—	6	—	—
7	5	—	—	16	—	—
8	11	—	—	10	—	—
13	10	2	—	35	3	—
14	7	14	23	44	2	104
15	5	6	13	42	3	40
16	8	12	8	41	4	85
17	5	11	12	33	13	61
18	3	4	5	26	10	33
19	0	4	2	8	1	6
20	1	0	—	3	0	—
21	0	0	—	2	0	—
22	1	0	—	0	0	—
23	0	—	—	1	—	—

whilst the majority of epiphyses had fused at the age of 17 in females, it was not until the age of 19 that union was present in the majority of men. The oldest female in whom this centre had not yet fused was aged 22 and the oldest male 23. Paterson's conclusion, "it joins the shaft at the same time as the radius namely at 21 in males and a year earlier in females," implies a rather later date of fusion than is the case with the majority of the Australian series, although it is true that fusion of the lower epiphyses of the radius and ulna are almost simultaneous.

Similar remarks made in reference to the lower end of the radius would

also apply to the lower end of the ulna. Thus it would appear in Galstaun's Hindu series, that, with the exception of a few instances, fusion does not take place generally at an earlier age than in this Australian series of European descent.

Sidhom and Derry found that the majority of Egyptian males aged 18 show fusion, which is a year earlier than in the Australian series. In one boy fusion was present at the age of 15 years and 11 months.

Pryor found union in the majority of American girls at 16 and boys at 19, in each case earlier than in the Australian series, although the boys are later than in the Egyptian series.

STYLOID PROCESS OF THE ULNA

Borovansky and Hnevkovsky found a separate epiphysis for this process in a boy aged 5 years and 10 months on both sides. They report two instances of this epiphysis, one of which is illustrated.

In one boy aged 13 years and 10 months a separate ossicle representing the detached styloid process of the ulna was seen. This does not appear to have been caused by injury. In view of the frequency with which the styloid process is detached by trauma, it is important to recognise that this process may exist independently as a separate centre.

CARPAL BONES

These are all developed from a single centre as a rule. Woollard states that two centres have been found for the navicular, Pfitzner has described a double centre for the triquetrum, whilst Quain reports two centres being sometimes found for the lunate. In this series (see figs. 3 and 4) double centres for the lunate, one dorsal to the other, have been noted in a girl aged 6 and in boys aged 4 years and 7 months and 8 years respectively. Pryor has noted in a girl aged 7 years and 6 months a double centre for the multangulum minus on the right side, but not on the left. Borovansky and Hnevkovsky found these present on both sides in a boy aged 5 years and 10 months.

The order of appearance is by no means constant, for even in the same individual it may be different on each side. Thus, in a boy (see fig. 2) aged 6 years and 11 months, the multangulum majus was well marked on the left but completely absent on the right; the lunate had just appeared on the right side although no trace could be observed on the left. Pryor states that the order of appearance is a peculiarity of the family.

The first carpal bone to appear is usually the capitate, shortly followed by the hamate. Then follow the triquetrum, multangulum minus, lunate, multangulum majus, navicular and invariably last of all at a considerably later date, the pisiform, but there is considerable variation in the respective order of appearance of the lunate, multangula majus and minus and the navicular. In a female aged 3 months and a male aged 7 months, Pryor noted the appearance of the hamate before the capitate.

THE NAVICULAR

	Instances in girls		Instances in boys		Centres in girls		Centres in boys	
Age	Author	Pryor	Author	Pryor	Author	Pryor	Author	Pryor
3	6	9	11	3	0	1	0	1
4	0	14	5	14	0	7	1	1
5	3	30	7	39	2	19	4	8
6	7	35	10	42	7	30	9	20
7	7	14	22	10	7	14	20	9
8	11	4	12	8	11	4	11	6

The earliest centres noted were in a boy aged 4 years and 6 months and girls aged 5. It was present in the majority of both sexes at the age of 5. The oldest subjects showing absence of centres were a girl aged 5 years and 5 months and a boy aged 8. Woollard states that two centres have been found for the navicular. This is important in considerations of fractures of this bone.

Pryor found this centre in a girl aged 3 years and 6 months and in a boy aged 4 years and 4 months. The majority of the girls aged 4 and boys aged 6 showed its presence. In his series it was not present in a girl aged 6 years and 4 months nor in a boy aged 8 years and 3 months.

THE LUNATE

	Instances in girls		Instances in boys		Centres in girls		Centres in boys	
Age	Author	Pryor	Author	Pryor	Author	Pryor	Author	Pryor
1	6	3	5	2	0	0	1	0
2	9	4	10	2	3	1	1	0
3	6	9	8	3	2	5	4	0
4	0	14	5	14	0	13	3	10
5	3	30	8	39	3	26	6	31
6	7	35	9	42	7	30	8	20

This centre sometimes appears before the triquetrum and sometimes afterwards. The youngest subjects showing this centre were a boy in his second year and a girl aged 2 years and 7 months. It was found present in the majority of boys aged 4. Its absence was noted in a girl aged 3 years and 5 months, in one instance on both sides, and in a boy aged 6 years and 11 months, where it was present on the opposite side. On one side it was the only carpal bone absent except the pisiform.

Pryor found this centre in the majority of girls aged 3 and of boys aged 5. It was absent in a girl aged 6 years and 3 months.

In a girl aged 6 (see figs. 3 and 4) and boys aged 4 years and 7 months and 8 years respectively, two centres, one dorsal to the other, were noted for this bone. Pryor has noted on both sides in a boy aged 6 years and 4 months both the triquetrum and lunate to be possessed with double centres.

A small centre immediately alongside the lunate on the ulnar side is figured by Borovansky and Hnevkovsky, under the title "hypolunatum?"

THE TRIQUETRUM

	Instances in girls		Instances in boys		Centres in girls		Centres in boys	
Age	Author	Pryor	Author	Pryor	Author	Pryor	Author	Pryor
1	8	3	3	2	5	1	0	1
2	10	4	9	2	1	3	3	0
3	7	9	11	3	3	9	7	2
4	0	14	5	14	0	14	4	11
5	3	30	8	39	3	30	8	36

This centre is usually the earliest of the carpal bones to appear after the capitate and hamate, but may be preceded by the lunate. The earliest centres were noted in a female at the age of 1 year and 6 months and in males at the age of 2 (in one instance on both sides). It was found in the majority of boys aged 3. Its absence was noted in girls at the age of 3 and in a boy aged 4.

THE PISIFORM

This is the last of all the carpal bones to ossify, and is not always easy to detect when it first appears, as it frequently lies directly over the triquetrum, but a lateral or oblique view often shows its presence when it cannot be seen in the ordinary anterior view.

	Instances in girls		Instances in boys		Centres in girls		Centres in boys		
Age	Author	Pryor	Author	Pryor	Author	Pryor	Author	Pryor	Paterson
7	6	14	25	11	0	1	2	0	
8	8	8	12	9	2	2	0	0	
9	5	4	6	8	2	2	1	0	
10	5	5	8	6	4	4	2	0	
11	6	3	14	5	6 100 %	3	8 61 %	1	25 %
12	14	2	17	5	13 100 %	2	11 73 %	2	55 %
13	12	0	34	3	12 100 %	0	26 86 %	2	80 %
14	8	0	45	1	8 100 %	0	38 92 %	0	100 %

The youngest boys noted with this centre were aged 7 and the youngest girl 8 years and 6 months. It was present in half of the girls at the age of 9 and the majority of boys at 11. The oldest girl in whom it was not present was aged 10 and the oldest boy 14 years and 7 months. Pryor found the centre present in a girl aged 7 years and 7 months, but absent in another girl aged 10 years and 7 months.

The percentages at each age are compared with the figures given by Paterson, the latter appearing to be a rough estimate only. In females, it was present in all of 40 instances at the ages 11 to 14, that is 100 per cent. Thus, in this series, this bone was rather more frequently demonstrable than is estimated by Paterson.

HAMATE

Except for the capitate, this is usually the first carpal bone to appear and was present in all babes of 10 months of both sexes and older, but was not present on either side in an infant aged 6 months. It was present in all four instances in babes aged 10 and 11 months. Davies and Parsons found it

absent in a child aged 1 year and 3 months. Pryor found it present in a child aged 3 months (female) and a male aged 7 months.

CAPITATE

This is the first carpal bone to appear. In one babe aged 6 months the centre for the capitate was present on both sides, although those for the hamate were absent. In a male child 1 week old the centre was not present. Pryor found it present in a male child aged 2 days, and in a female aged 4 days, but absent in a female aged 3 months and a male aged 7 months, in each case in the presence of the hamate.

MULTANGULUM MINUS

	Instances in girls		Instances in boys		Centres in girls		Centres in boys	
Age	Author	Pryor	Author	Pryor	Author	Pryor	Author	Pryor
3	6	9	9	3	1	1	0	0
4	0	14	5	14	0	7	1	0
5	4	30	5	39	4	24	2	9
6	7	33	9	41	7	28	7	18
7	6	14	26	10	6	14	25	7
8	10	4	10	8	10	4	9	7

The youngest girl showing this centre was aged 3 years and 5 months, where it was present on the right side but absent on the left, and the youngest boy was aged 4 years and 6 months. The centre was present in the majority of cases at the age of 5 in girls and 6 in boys. In a girl aged 3 years and 5 months it was absent, likewise in a boy aged 8. Pryor found it present in the majority of girls at the age of 4 and boys at 6. He found it absent in a girl aged 6 years and 7 months and in a boy aged 8 years and 3 months. He also found it duplicated in a girl aged 7 years and 6 months, whilst Borovansky and Hnevkovsky likewise found it duplicated in a boy aged 5 years and 10 months.

MULTANGULUM MAJUS

	Instances in girls		Instances in boys		Centres in girls		Centres in boys	
Age	Author	Pryor	Author	Pryor	Author	Pryor	Author	Pryor
3	6	9	9	3	1	0	0	0
4	0	14	4	14	0	6	0	5
5	3	30	6	39	3	20	5	11
6	6	33	9	41	6	26	7	15
7	6	14	24	10	6	14	23	8
8	10	4	9	8	10	4	8	6

The youngest girl showing this centre was aged 3 years and 5 months, the youngest boy 5. In one girl aged 3 it was not present on either side, whilst in a boy aged 8 it was found absent. In both sexes it was found in the majority of cases at the age of 5 years.

Pryor found the centre present in a boy aged 4 years and 1 month. He found it present in the majority of boys at the age of 7 and noted its absence in a girl aged 6 years and 7 months, and a boy aged 8 years and 10 months.

FIRST METACARPAL BONE

The epiphysis for this bone, unlike those of the other metacarpals, appears at the base instead of at the distal extremity. Additional centres also frequently are found for the distal extremity, in fact Borovansky and Hnevkovsky estimate that 50 per cent. of the boys of Prague present this epiphysis, whilst indications of its tendency may be noted in 70 per cent. by a fissure.

	Instances in females		Instances in males		Centres in females		Centres in males	
Age	Author	Galstaun	Author	Sidhom and Derry	Author	Galstaun	Author	Sidhom and Derry
1	6	—	4	—	5	—	0	—
2	10	—	7	—	7	—	4	—
3	6	—	7	—	6	—	5	—
13	12	—	28	—	11	—	28	—
14	3	24	42	110	2	13	40	100
15	5	16	41	42	3	6	37	28
16	13	12	37	101	0	1	28	32
17	10	16	43	96	0	3	25	10
18	19	9	33	71	0	1	4	5
19	5	2	37	24	0	0	2	0

The centre was seen earliest in a girl aged 1 year and 2 months and a boy aged 2 years and 6 months. It was present in the majority of girls during their second year and boys aged 2. Its absence was noted in a girl aged 2 years and 5 months and in boys aged 3.

The youngest female where the epiphysis had fused was aged 13, the youngest males 14. Fusion was complete in the majority of females at the age of 16 and the majority of males at 18. Fusion had not yet occurred in girls aged 15 nor in one man aged 19 years and 7 months.

SECOND, THIRD, FOURTH AND FIFTH METACARPAL BONES

The epiphyses for these usually appear, unlike those of the phalanges and the first metacarpal, at the distal extremities of the bones. Sometimes additional epiphyses appear at the proximal extremities of the second and very rarely of the fifth. Even when such a centre is not quite detached, an indication of such tendency is shown by the appearance of a constriction or fissure, instead of the usual epiphyseal interval. Epiphyses at the base of the second metacarpal were noted in a girl aged 3 and in a boy aged 7 years and 11 months. Very large epiphyses were present on each side in a boy aged 9 years and 8 months, who is the subject of cleidocranial dysostosis.

	Instances in girls					Instances in boys			
	Author				Galstaun				
Age									
1	1	1	3	3	—	3	1	3	3
2	8	8	9	9	—	6	6	6	6
3	4	4	5	5	—	5	6	6	6
14	2	2	2	2	24	24	23	26	28
15	8	8	8	8	16	19	21	20	21
16	11	9	9	8	12	22	23	21	20
17	7	6	9	11	16	26	27	28	30
18	17	16	14	18	9	27	26	28	25
19	3	3	4	4	3	30	30	26	29
20	8	8	10	11	—	16	18	18	18

Age	Centres in girls: Author				Centres in girls: Galstaun				Centres in boys			
1	1	1	1	1	—	—	—	—	2	1	1	1
2	7	7	6	6	—	—	—	—	5	4	4	2
3	4	4	5	5	—	—	—	—	5	5	5	5
14	2	2	2	2	10	10	9	9	24	23	26	28
15	5	7	6	6	7	7	7	7	19	21	20	21
16	2	1	1	1	1	1	1	1	21	22	20	18
17	1	1	1	1	4	4	4	4	16	18	21	22
18	1	0	0	0	1	1	1	1	6	6	7	6
19	0	0	0	0	0	0	0	0	3	3	2	2
20	0	0	0	0	—	—	—	—	1	1	0	0

The youngest subject with epiphyses for the fourth metacarpal was a girl aged 1 year and 10 months and for the fifth metacarpal 1 year and 5 months. In a female aged 1 year and 11 months centres for the first, second and third metacarpals were present, but those for the fourth and fifth were absent. In a boy in his second year centres were present for all metacarpals except the first. The epiphyses were present in the majority of both sexes during the second year for the second and third metacarpal bones and in the majority of both sexes for the fourth metacarpal at the age of 2. The majority of centres for the fifth metacarpal appear at the age of 2 in girls and 3 in boys. In a girl aged 2 years and 5 months and a boy aged 2 no centres were present in any of the metacarpals, whilst in another boy of 3 there were none for the middle, ring or little finger.

Except for the second metacarpal in a girl aged 14 years and 9 months the earliest to fuse in each of these metacarpals were in females at the age of 15 and in a male at 16 years. Union takes place in the majority of girls at 16 and boys at 18 years of age. In a girl aged 17 none of the centres for these bones had fused, and in another girl aged 18 the centre for the second metacarpal was still ununited. In 2 men aged 19 none of the centres for these metacarpal bones was united, whilst in another male of the same age the centre for the third metacarpal was still present although those for the second, fourth and fifth had fused with their respective diaphyses. Non-fusion of the second and third metacarpals was likewise present in a male aged 20 years and 7 months.

Palmer has found all the epiphyses for the metacarpal bones fused in the skeleton of a girl aged 14 years and 5 months.

Like Pryor, the author has not met with any example of a separate epiphysis for the styloid process of the third metacarpal bone mentioned by Cunningham and Morris.

According to Galstaun's figures, fusion appears to be complete in the majority of instances at the age of 14, which is 2 years earlier than is the case with the Australian series.

PHALANGES OF THE HAND

Paterson's statement that the phalangeal epiphyses appear "for all practical purposes in all three rows simultaneously," is not borne out by careful study, as the following account shows. Those for the thumb, for

instance, generally appear before the other phalanges. Nor are the other phalanges, even in the same row, always simultaneous in their genesis.

Paterson likewise reports that there are no cases of epiphyses in males before the third year, but in the proximal phalanges, at least, instances were seen in both sexes during the second year, and in a female infant of 10 months they were present in the proximal phalanx of the thumb as well as in the middle phalanges of the middle and ring fingers, although absent in the little finger. Davies and Parsons found the centre in each phalanx of the proximal row in an infant aged 9 months.

PROXIMAL PHALANX OF THE THUMB

Age	Instances in females	Instances in males	Centres in females	Centres in males
1	1	3	1	0
2	8	6	4	0
3	4	2	4	2
13	7	14	5	14
14	2	27	2	26
15	6	24	3	24
16	8	22	0	12
17	14	26	0	12
18	16	23	0	3
19	2	30	0	4

The earliest epiphyseal centres to appear were in a girl aged 1 year and 11 months and in a boy aged 3 years and 10 months. It was found in all six instances at 3 years of age. It was absent in a girl aged 2 years and 5 months where it was present in all the other proximal phalanges, and likewise was not present in a boy aged 2 years and 6 months. It was present in half the instances in girls at the age of 2.

The earliest centres to fuse were in a girl aged 13 years and 8 months and a boy aged 14. Fusion was complete in half of the instances in girls at the age of 15 and of boys at 17 years of age. The latest unfused were in a girl aged 15 years and 6 months and in a man aged 19 years and 11 months, in whom all the other phalanges of the row were found fused.

PROXIMAL PHALANGES OF INDEX, MIDDLE, RING AND LITTLE FINGERS

Age	Instances in girls				Instances in boys				Centres in girls				Centres in boys			
Under 1	0	1	2	2	1	1	1	1	0	1	1	1	0	0	0	0
1	3	2	2	3	2	2	2	2	3	2	2	2	2	2	2	2
2	7	6	7	5	5	5	5	6	7	6	7	5	4	4	4	4
3	4	4	4	4	2	3	3	3	4	4	4	4	2	3	2	2
13	6	8	7	7	8	6	6	7	5	7	7	6	8	6	6	7
14	4	2	2	3	18	17	19	19	4	1	1	2	17	16	18	18
15	8	8	7	5	19	18	18	18	7	5	4	3	17	17	17	18
16	6	11	11	8	21	22	19	20	1	1	2	1	18	18	16	17
17	6	4	2	9	27	27	28	23	0	0	0	0	15	16	14	15
18	16	13	14	14	25	29	26	24	0	0	0	0	4	4	3	4
19	3	3	3	2	28	28	30	30	0	0	0	0	3	2	2	2

These centres all appear considerably earlier than in the case of the thumb. The youngest female to show centres for these was aged 10 months, where they were present in the middle finger of the left hand and ring fingers

of both hands, but absent in the little fingers on both sides. The earliest centres for the index finger had appeared in a girl aged 1 year and 4 months and in a boy in his second year, whilst the earliest for the little finger were noted at 1 year and 10 months in a girl and in the second year in a boy. Davies and Parsons found the centres present in all the digits of the proximal row in a child aged 9 months.

In the majority of children of both sexes, centres had appeared in all four phalanges during their second year. In every instance centres were found in girls over the age of 10 months. In a boy aged 3 years centres for the ring and little fingers had not yet appeared.

The youngest subject with a fused epiphysis was a girl aged 13 years and 8 months in the case of the index and middle fingers and a girl aged 13 in the case of the little finger. In a girl of 14 it was fused in the middle, ring and little fingers, but not in the index. In a boy of 14 it was fused in all four digits. In the great majority of girls fusion was completed at the age of 16, and of boys at the age of 17 for the ring finger and 18 for the other digits. In a girl aged 16 fusion had not yet occurred in any of the four proximal phalanges. In a man aged 19 likewise none was fused, whilst in one man aged 19 years and 7 months the centre for the phalanx for the index finger was still present.

MIDDLE ROW OF PHALANGES

Age	Instances in females				Instances in males				Centres in females				Centres in males			
1	3	2	2	2	2	2	2	2	1	1	1	0	0	0	0	0
2	3	3	3	2	3	3	4	3	2	2	2	1	0	0	0	0
3	1	1	1	2	0	2	1	0	1	1	1	1	0	2	1	0
13	4	4	5	4	7	6	5	5	3	4	5	4	7	6	5	5
14	2	3	3	2	17	15	15	15	2	3	3	2	15	14	14	14
15	7	7	6	5	12	12	11	12	5	6	5	4	10	11	10	11
16	2	8	7	4	18	19	13	10	0	1	1	0	12	13	9	8
17	2	3	2	3	16	16	19	17	0	0	0	0	6	7	9	9
18	12	12	11	10	18	20	18	19	0	0	0	0	1	1	3	2
19	1	1	0	2	23	27	24	24	0	0	0	0	3	2	2	2

In the case of the index finger, the youngest girl with fused epiphysis was aged 13 years and 8 months. In a boy aged 14 the centres for the index, ring and little fingers had fused, although that for the middle finger had not yet united. The youngest boy with fused centre for the middle finger was aged 15. In a girl aged 15, all four epiphyses were fused, whilst the oldest girls with unfused centres for the middle and ring fingers were aged 16. The oldest males with unfused centres were aged 19 where they were present in the whole row. The majority of centres unite at the age of 16 in females and 17 in males except for the little finger which unites at 18.

DISTAL PHALANX OF THE THUMB

The youngest subject with a centre for this epiphysis was a female infant aged 10 months, where the centres were also present for the bases of the proximal phalanges of the middle and ring fingers. It was also seen in a male

infant, 1 year old, where none of the epiphyses for the middle row was present, although present in all of the proximal row except that for the thumb and all of the metacarpals except the first. The centre had not yet appeared in a female child 1 year and 10 months old nor in a male aged 2.

		Instances in males			Centres in males	
Age	Instances in females	Author	Sidhom and Derry	Centres in females	Author	Sidhom and Derry
13	4	5	—	2	5	—
14	2	15	102	1	14	86
15	6	14	40	2	13	15
16	6	10	95	0	7	15
17	4	26	90	0	8	9
18	12	15	70	0	1	3
19	3	29	—	0	3	—

The earliest centres to fuse were at the age of 13 years and 8 months in a girl and 14 in a boy. Half had fused at the age of 13 in females and the majority at 17 in males. The oldest female with unfused epiphysis was aged 15 and the oldest male 19 years and 7 months.

Sidhom and Derry found fusion to take place in the majority of Egyptian boys at the age of 15, that is two years earlier than the Australian series.

DISTAL PHALANGES OF INDEX, MIDDLE AND RING FINGERS

In a girl aged 1 year and 11 months the centres were present in the middle and ring fingers but absent in the index and little fingers. In a boy aged 2 the epiphyseal centre was present in the index finger on one side only, but absent on the other side as well as in all the other distal phalanges on both sides. One child aged 3 showed no epiphyses in any of these fingers. In a boy aged 2 years and 6 months the centre for the ring finger had not yet appeared.

	Instances in females				Instances in males				Centres in females				Centres in males			
Age																
14	2	3	3	3	14	11	12	12	1	2	2	3	13	10	11	11
15	7	7	7	5	6	7	8	9	3	2	2	2	5	6	8	8
16	6	6	7	4	8	12	8	9	0	0	1	0	5	5	7	7
17	4	2	3	4	14	14	16	16	0	0	0	0	6	6	6	7

In a girl aged 14 years and 9 months the centre for the index finger had fused. In a boy aged 14 the centres for all these phalanges had fused, whilst in a girl of the same age the centres for the epiphyses of the middle and ring fingers had united with the diaphyses. In a girl aged 15 years and 6 months the centres were fused in the case of all the digits. In the female the majority of the epiphyses fuse at the age of 15, in the male at 16 for the middle finger and 17 for the index, ring and little fingers. Thus it appears that the centre for the middle finger fuses at an earlier date than the others in the male at least. Unfused epiphyses were present for all fingers at the age of 15 in females, and for the ring finger in a girl aged 16, whilst the oldest male with non-fusion for all the distal phalanges (both sides) was aged 17.

SESAMOID OSSICLES

Sesamoid ossicles, usually two, are practically constantly found over the heads of the first metacarpal bones on the palmar aspect. Similar ossicles, usually single, are generally, but not invariably, found over the heads of the second metacarpal on the radial side and the fifth metacarpal bone on the ulnar aspect, but similar ossicles over the third and fourth are rather rare. Usually, also, very much smaller ossicles are present in the tendon of the flexor longus pollicis beneath the head of the proximal phalanx of the thumb, and these are always single.

PROXIMAL SESAMOID BONES OF THUMB

Age	Instances in females	Instances in males	Centres in females	Centres in males
11	2	5	2	0
12	5	4	2	0
13	3	1	3	0
14	2	10	2	9
15	5	16	5	15

The earliest instances were noted in a girl aged 11 years and 5 months and a boy aged 14 years and 5 months, the majority of girls aged 13 and of boys aged 14 showing sesamoids. It was absent on both sides in girls aged 12 and also absent in a boy aged 15. It was likewise noted absent in a subject aged 17 of unknown sex.

SESAMOID OF INDEX FINGER

Age	Instances in females	Instances in males	Sesamoids in females	Sesamoids in males
11	3	1	1	0
12	4	2	1	0
13	3	1	0	0
14	1	7	0	2
15	6	5	3	2
16	4	8	4	5
17	3	11	3	3
18	5	14	1	5
19	3	16	1	9
20	5	9	4	5
21	2	11	2	9
22	2	11	1	5
23	6	9	3	8
24	1	7	1	4
25	0	3	0	2
26	0	1	0	0
27	0	1	0	0
28	0	1	0	1

The earliest examples were noted in a girl aged 11 years and 6 months. It is present in half of the girls at 15 and the majority of young men at 19. However, it is commonly absent at a much later date; thus it was not present on either side in a woman of 23 although present over the fifth metacarpals, nor was it present in a man aged 27. Older subjects were not studied, but it is likely that in certain individuals it may never appear.

SESAMOIDS OF MIDDLE AND RING FINGERS

These are rare. An instance was noted in a girl aged 13 years and 10 months. In a man aged 21 (fig. 5) sesamoid bones were present at the heads of all the metacarpals, those for the middle and ring fingers being on the radial aspects, whilst two were present for the fifth metacarpal. In another subject (fig. 6) of the same age of unknown sex a very large sesamoid appeared to be situated over the middle of the head of the third metacarpal bone.

SESAMOID OF LITTLE FINGER

Age	Instances in females	Instances in males	Sesamoids in females	Sesamoids in males
13	5	1	1	0
14	0	6	0	0
15	5	11	4	4
16	4	10	4	4
17	4	13	4	6
18	4	21	3	12
19	3	15	2	10
20	8	9	8	5
21	3	11	3	10
22	6	13	5	9
23	6	13	5	13
24	3	6	3	4
25	0	4	0	4
26	0	4	0	2
28	0	1	0	1

The earliest examples were seen at the age of 13 years and 10 months in the female and 15 years and 0 months in a male. At the age of 15 in the female and 18 in the male the majority showed presence of these ossicles. However, instances were found at the age of 23 in the female and 27 in the male where they were not present.

DISTAL SESAMOID OF THUMB

This is a very small ossicle found at the head of the proximal phalanx of the thumb.

Age	Instances in females	Instances in males	Sesamoids in females	Sesamoids in males
15	0	6	0	2
16	3	4	3	2
17	2	7	2	5
18	3	8	3	5
19	1	8	0	6
20	3	4	2	4
21	0	6	0	5
22	1	3	1	2
23	0	7	0	5
24	0	4	0	1
25	0	1	0	1
26	0	1	0	1

The earliest sesamoids were seen at the age of 15 in boys and 16 years and 3 months in a girl. The majority of females aged 16 and half of the males aged 16 showed its presence. Examples of absence were noted at the age of 20 in the female and 24 in the male.

UNION OF ILIUM, ISCHIUM AND PUBIS

Age	Instances in females	Instances in males	Fusions in females	Fusions in males
10	2	8	2	0
11	10	10	2	0
12	7	13	1	0
13	4	5	2	3
14	7	10	4	7
15	9	12	9	8
16	12	8	11	6

The youngest girl in whom the cartilaginous junction (Y-shaped cartilage) of the three component parts of the os coxae had completely ossified was aged 10 years and 6 months and the youngest boy 13, in each case on both sides. Fusion had taken place in half of the girls at the age of 13 and the majority of boys not until 15 years of age. The oldest subjects with unfused centres were a boy aged 16 years and 3 months and a girl aged 16 years and 10 months.

UNION OF ASCENDING ISCHIAL WITH DESCENDING PUBIC RAMUS

In the ordinary antero-posterior view of the pelvis these rami are seen obliquely where they form the lateral boundaries of the perineum. The descending pubic ramus before fusion with the ischium forms a rounded protuberance somewhat overlapping the ischium, thus making it difficult to be sure in many cases whether union has actually taken place or not.

Age	Instances in females	Instances in males	Fusions in females	Fusions in males
3	15	20	2	0
4	10	12	2	0
5	6	23	4	7
6	1	9	0	2
7	8	20	4	11
8	9	8	8	3
9	7	5	7	4
10	1	8	1	6
11	6	8	5	8

The youngest girl showing fusion of the rami was aged 3 years and 11 months, the youngest boy 5 years and 9 months, on both sides in each case. Half showed union at the age of 7 in girls and the majority at the age of 9 in boys. Davies and Parsons noted fusion in a boy aged 3. In a boy aged 10 union was not complete on either side, but in a girl of 11 fusion was present on one side but not on the other.

EPIPHYSIS FOR THE ILIAC CREST

This varies greatly in length, and frequently consists of several detached fragments.

Age	Instances in females	Instances in males	Centres in females	Centres in males
14	6	7	5	0
15	11	5	11	2
16	16	8	16	5
17	14	15	10	10
18	26	20	24	14
19	13	18	7	13
20	28	12	15	6
21	17	17	6	3

The youngest subjects in whom these epiphyses were present were a girl aged 14 and a boy aged 15, where it was present on each side in each case. In females the majority of epiphyses appear at the age of 14 and in males at 16 years of age, but the maximum incidence is at 15 and 16 in girls and 18 in young men. Epiphyses were found present in females on both sides at the age of 21, and in the male at the age of 21 years and 7 months.

SYMPHYSIS PUBIS

An epiphysis for the symphysis such as is usually described by anatomists has not been found. The nearest approach was in a male subject aged 18 (see fig. 7), but this appears to be a forward extension of an epiphysis which may be found at any part of the perineal margin reaching from the tuber ischii to the lower margin of the symphysis. The epiphysis therefore, as is usually described, either does not exist or is very rare. Similarly no trace of any epiphysis about the pubic crest or pubic spine has been met with.

EPIPHYSIS FOR THE ANTERIOR SUPERIOR ILIAC SPINE

This appears to be a rare epiphysis and in this series was only met with twice, each time in females aged 14 and 17 respectively, in one of whom, at least, it was present on both sides. Possibly this epiphysis might be considered a separate fragment of the epiphysis for the iliac crest (see figs. 8 and 9).

EPIPHYSIS FOR THE TUBER ISCHII

The epiphysis for this process forms a thin scale of bone of variable size. Sometimes it extends forwards forming a thin scale along the ascending ramus of the ischium and descending ramus of the pubis even as far as the apex of the perineal triangle (see note concerning epiphysis for the symphysis). This is the epiphysis described by Stevenson as the ramal epiphysis which he regards as distinct from that of the tuber ischii (see fig. 7).

Age	Instances in females	Instances in males	Centres in females	Centres in males
13	4	7	2	1
14	6	12	2	0
15	2	12	0	1
16	7	8	6	0
17	3	12	2	4
18	10	14	6	5
19	7	13	6	8
20	21	10	18	2
21	4	11	2	3
22	20	8	3	0
23	6	9	0	0
24	15	11	2	0

The youngest boy in whom this centre was found was aged 13, and the youngest girl 13 years and 5 months, in each case being present on both sides. The above table appears to indicate that the epiphysis is present in the majority of females at the age of 16 and of males at the age of 19. The maximum incidence is at the age of 19 in both sexes. Fusion is present in the majority of males at the age of 20 and in half the females at 21. It seems to be much less frequently demonstrable between the ages of 13 to 24 in males (24 times in 127 instances = 18·9 per cent.) than in females (49 times in 105 instances = 46·6 per cent.). It was present on both sides in a man aged 21 and a woman aged 24.

HEAD OF FEMUR

The epiphysis for the head of the femur apparently always appears during the first year after birth. It was present in a male infant aged 6 months, but in each of two boys aged 9 months it was present on the right side, although absent on the left. A girl aged 10 months showed the centre on both sides. In all of five instances in boys and 19 in girls in their second year the centre was found. Davies and Parsons noted its presence in a girl aged 6 months, whilst Borovansky and Hnevkovsky found the centre in a boy aged 3 weeks.

Age	Instances in females	Instances in males	Centres in females	Centres in males
14	7	10	0	9
15	5	8	0	5
16	11	10	1	6
17	5	12	0	4
18	10	14	0	0
19	6	19	0	0
20	21	10	0	2

The youngest to fuse in each sex were girls aged 14 and a boy of 14, in the former instances on both sides. At the age of 14 the great majority had fused in girls, but not until the age of 17 in males had the majority united. This is much earlier than the dates given by Paterson, namely 17 for females and 18 for males. The oldest subjects with unfused epiphyses were 16 years and 10 months in a female and 20 years and 2 months in a male (both sides).

EPIPHYSIS FOR GREATER TROCHANTER

Age	Instances in females	Instances in males	Centres in females	Centres in males
2	10	12	2	0
3	15	18	9	0
4	10	10	4	3
5	8	21	8	16
6	6	4	6	2
14	7	9	0	9
15	2	5	0	2
16	6	4	1	3
17	3	9	0	4

The youngest girl with a centre for the greater trochanter was aged 2, where it was present on both sides, whilst the youngest boy was aged 4 years and 4 months. The majority of epiphyses appeared in both sexes at the age of 5 years. Borovansky and Hnevkovsky found this centre present in a boy aged 3 years and 5 months. The oldest girls in whom the epiphyses had not yet appeared on either side were aged 4, whilst in a boy of 6 the epiphyses were likewise absent on both sides.

The earliest to fuse were girls aged 14 and a boy of 15, in each case on both sides. The majority were fused in girls at the age of 14 and half in boys at 17. Union had not yet taken place in a girl aged 16 years and 10 months nor in a boy aged 17 on either side.

EPIPHYSIS FOR LESSER TROCHANTER

Age	Instances in females	Instances in males	Centres in females	Centres in males
10	0	9	0	1
11	9	10	3	0
12	5	9	0	6
13	4	4	0	0
14	5	13	0	11
15	4	7	0	4
16	7	8	1	4
17	3	10	0	2

The youngest girls with epiphyses for this process were aged 11 (in one on both sides) and the youngest boy 10 years and 9 months, where it was present on the left side but not on the right. At the age of 14 it was present in boys in the great majority of cases. The maximum incidence was in girls at the age of 11 and boys at the age of 14. Although the centre was present in 28 of 70 instances in boys aged 10 to 17, it was only noted four times in 39 instances in girls of the same ages. It seems probable that this centre is not constantly present and perhaps is much more common in boys than in girls. The centre was found present in a girl aged 16 years and 10 months, and in boys aged 17. It was likewise found in a female aged 24, but no explanation can be given for this extreme delay in union.

DISTAL EPIPHYSIS OF FEMUR

The centre for the distal extremity of the femur was found in every infant examined, including 13 in their first year. It usually appears before birth.

Pryor noted the presence of epiphyses in each of 2 females within 2 days after premature birth at 8 months, but it was not present in a male under similar circumstances. Of 43 boys and 48 girls during the first 9 days after birth, this epiphysis was present in every instance except 2 boys.

Age	Instances in girls	Instances in boys	Centres in girls	Centres in boys
14	5	8	4	8
15	6	8	3	8
16	7	12	4	10
17	6	17	0	11
18	8	11	1	6
19	4	12	1	1

The youngest girl in whom this epiphysis had fused was aged 14, the youngest boys 16. The centre was fused in the majority of females at the age of 17 and in the majority of males at 19. Instances of non-fusion were met with in both sexes at the age of 19.

THE PATELLA

This bone is best demonstrated in young children in the lateral view of the knee joint, for its absence cannot always be determined in the postero-anterior view as the bone may be hidden over the shadow of the lower end of the femur.

Sometimes an additional centre on the upper and outer aspect is present. This forms the patella bipartita or patellula. Borovansky and Hnevkovsky found one in a boy aged 14. In this series an example was seen in a female aged 27 years and 6 months. Borovansky and Hnevkovsky also figure a separate ossicle at the apex of the patella in a boy aged 16 years and 11 months.

Age	Instances in females	Instances in males	Centres in females	Centres in males
2	5	6	1	0
3	2	4	1	0
4	1	6	1	2
5	6	3	6	3
6	1	4	1	4
7	2	7	2	7
8	1	7	1	6

The youngest girl showing a centre for the patella was aged 2 years and 6 months, the youngest boy 3 years and 11 months. It was present in the majority of girls from the age of 3 and of boys at the age of 5. In a girl aged 3 years and 0 months and a boy aged 8 the bone had not yet appeared. Borovansky and Hnevkovsky found a centre present in a boy aged 3 years and 7 months.

THE FABELLA

Of this series the youngest female showing this sesamoid bone was aged 17, the youngest male being 16 years and 5 months of age. It is by no means common, for of 160 knees of individuals aged 16 to 29 it was present in 16 instances only, that is in 10 per cent.

The author has learnt of an instance where this ossicle was removed surgically under the impression that it was a pathological foreign body.

PROXIMAL EPIPHYSIS OF THE TIBIA

This was present in every infant examined and usually appears before birth.

Pryor noted this centre present 2 days after premature birth at 8 months in a female, but was absent in a male and a female after premature birth at 8 months. Of 47 female and 42 male infants in the first 9 days after birth this centre was noted absent in 7 females and 13 males, being relatively twice as frequently absent in boys as in girls. Its absence was also noted in a girl aged 25 days.

Age	Instances in girls	Instances in boys	Centres in girls	Centres in boys
14	6	8	5	8
15	5	9	2	9
16	7	10	1	8
17	6	17	0	11
18	10	10	1	4
19	4	16	1	2

The tongue-shaped prolongation which forms the anterior tubercle is not usually present until after the age of 8. Usually it is an extension of the proximal epiphysis forward over the upper end of the diaphysis. Sometimes an additional centre is present over this process.

The earliest to fuse were in a girl aged 14 and a boy aged 16 (both sides). Although the centre had disappeared in the majority of girls at the age of 15, it was not until the age of 18 that the majority of epiphyses in boys had united. Instances of non-fusion were found in both sexes at the age of 19.

PROXIMAL EPIPHYSIS OF THE FIBULA

Age	Instances in girls	Instances in boys	Centres in girls	Centres in boys
3	5	9	3	3
4	6	12	5	5
5	7	5	7	4
14	5	7	4	7
15	4	10	1	10
16	6	10	4	8
17	6	16	0	11
18	9	11	1	7
19	5	14	0	1

The earliest centres noted were in a girl aged 3 years and 11 months and on both sides in a boy aged 3 years and 4 months. Paterson records its presence in a girl aged 2. It was present in the majority of girls at the age of 3 and of boys at 5. Its absence was noted in a girl aged 4 and a boy aged 5.

The earliest epiphyses to fuse were in a girl aged 14 and a boy aged 16. The majority were fused at the age of 17 in females and 19 in males. The oldest subjects in whom fusion had not yet occurred were a female aged 18 and a male aged 19.

DISTAL EPIPHYSIS OF THE TIBIA

This was found to be present in every infant examined including a girl aged 7 months (both sides) and a boy aged 9 months. Borovansky and Hnevkovsky found its presence in a boy aged 3 months and 3 weeks.

Age	Instances in girls	Instances in boys	Centres in girls	Centres in boys
13	13	7	12	7
14	5	19	2	19
15	6	12	0	10
16	10	8	3	6
17	5	22	0	7
18	8	14	0	1

The youngest girl to show fusion of this epiphysis was aged 13 and the youngest boys 15. The above table shows that the majority of epiphyses fuse at the age of 14 in girls and 17 in boys. Instances of non-fusion were noted in a female aged 16 years and 4 months and a male aged 18.

As is the case with the distal epiphysis of the radius and ulna, so are the distal tibial and fibular centres fused approximately simultaneously with the shaft. However, in the girl of 13 quoted above, although the centre for the distal end of the tibia had fused, that for the fibula had not yet done so, being thus a violation of the oft-quoted rule that the first epiphyses to appear are the last to unite.

In a male aged 17 years and 7 months an ossicle was seen on both sides at the tips of the medial malleoli, and is clearly demonstrable in both the antero-posterior and lateral views. The author can nowhere find a record of such an ossicle in the literature. The term os malleoli medialis is suggested.

DISTAL EPIPHYSIS OF THE FIBULA

This was found present on both sides in a female infant aged 11 months, and was likewise found in a boy aged 9 months, but was not present in a girl of 7 months nor in a boy aged 1 year and 8 months, although present in 3 of 4 boys and all of 5 girls during their second year.

Age	Instances in females	Instances in males	Centres in females	Centres in males
14	5	18	2	18
15	6	12	0	10
16	10	10	3	8
17	5	21	0	6
18	7	13	0	1

The earliest epiphyses to fuse were found in a girl aged 14 years and 10 months and boys aged 15. The majority had united in girls at the age of 14 and in boys at 17. Instances of non-fusion were noted in a girl aged 16 years and 4 months and in a boy aged 18.

TARSAL BONES

No infant was found in which the centres for the talus, calcaneum, cuboid or third cuneiform had not already appeared. The calcaneum usually has an additional apophysis for the posterior aspect of the heel. The other tarsal bones usually ossify from a single centre, but sometimes the talus has a separate centre for the medial tubercle, which, when it fails to unite with the primary centre, forms the os trigonum. In this series, both the navicular and the first cuneiform have been noted arising from two centres.

Pryor found centres for both calcaneum and talus present in all of 3 premature 8 months' babes of both sexes, as well as in all of 90 other infants of both sexes during the first 9 months after birth.

APOPHYSIS OF THE CALCANEUM

Age	Instances in girls	Instances in boys	Centres in girls	Centres in boys
7	3	6	1	1
8	2	6	2	3
12	1	6	0	6
13	12	8	9	8
14	4	16	1	15
15	7	6	0	4
16	10	14	2	7
17	3	18	0	2
18	7	10	0	1

The earliest centres to appear were in a girl aged 7 years and a boy aged 7 years and 5 months. Borovansky and Hnevkovsky noted the centre in a boy aged 6 years and 2 months. It was absent in a girl aged 7 and in a boy aged 8 years and 7 months, but was present in all of 16 instances in children aged 9 to 11 years.

The earliest to fuse with the primary centre were a girl aged 12 years and 10 months and boys aged 15. The apophyses were fused in the majority of girls aged 14 and in half of the boys aged 16. The oldest subjects with ununited apophyses were a female aged 14 and a male aged 18.

THE CUBOID

A centre for this bone was present in every foot in the series examined.

Pryor found it present in a female 2 days after premature birth at 8 months, but was absent in another female and in a male, both also prematurely born at 8 months. He also examined 89 infants, 42 males and 47 females, during the first 9 days after birth and found the centre present in 31 females and 11 males, that is approximately 64 per cent. in girls and 25 per cent. in boys. It was, however, found absent in a boy aged 13 days and in a girl aged 25 days.

TARSAL NAVICULAR

Age	Instances in girls	Instances in boys	Centres in girls	Centres in boys
1	3	2	3	0
2	7	7	5	3
3	8	8	7	7
4	6	7	6	7
5	3	10	3	9

The youngest girl with centre for the navicular was aged 1 year and 3 months, the youngest boy 2 years and 6 months. In a girl aged 3 and a boy aged 5 the centre had not yet appeared. The centre was present in the majority of girls during their second year and of boys at the age of 3.

In a boy aged 3 two centres were present for this bone.

FIRST CUNEIFORM

Age	Instances in females	Instances in males	Centres in females	Centres in males
1	2	1	2	0
2	8	5	8	3

The youngest female with centre for this bone was aged 1 year and 8 months, the youngest males 2 years and 6 months. Davies and Parsons found it present in a girl aged 12 months. It was found present in the majority of instances in girls during their second year and in boys aged 2. Its absence was noted in a girl aged 11 months and a boy aged 2 years and 2 months. Although Woollard has stated that a double centre for this bone has not been satisfactorily demonstrated in a roentgenograph, an instance of two centres is noted in a girl aged 2 years and 3 months (fig. 10).

SECOND CUNEIFORM

Age	Instances in females	Instances in males	Centres in females	Centres in males
1	2	1	2	0
2	7	5	6	2

As with the first cuneiform, the youngest girl with a centre was aged 1 year and 8 months, the youngest boy being aged 2 years. In a boy aged 2 years and 6 months it was absent although present in the first cuneiform. It was found absent in a girl aged 2 years and 6 months on the right side, although present on the left, as well as in another boy aged 2. Davies and Parsons noted the absence of this bone in a child aged 3. It was present in the majority of girls during the second year and in half of the boys at the age of 2.

THIRD CUNEIFORM

The centre for this bone was found in every infant examined, even when the first and second cuneiforms were absent. Davies and Parsons noted its presence at the age of 4 months. It certainly appears before the other cuneiforms and the navicular.

FIRST METATARSAL

Age	Instances in girls	Instances in boys	Epiphyses in girls	Epiphyses in boys
2	6	4	5	2
3	5	4	5	3
14	1	7	0	7
15	3	4	0	3
16	7	10	2	8
17	3	16	0	3
18	5	9	1	1

The earliest epiphyses to appear were in a girl aged 2 years and 6 months (both sides) and in a boy also aged 2 years and 6 months. In the former it was present on both sides in the first, second and third, but not in the fourth and fifth metatarsals, in the latter absent in the four other metatarsals. In another girl aged 2 years and 7 months it was also present in the first but absent in all the others. The centre was absent in a girl aged 2 years and 4 months and in a boy aged 3 years and 6 months. It was present in the majority of instances in girls and half of those in boys at the age of 2. Davies and Parsons report the presence of an epiphysis in a female aged 10 months.

The earliest to fuse were in a girl aged 14 and a boy aged 15. Although the majority of girls aged 14 showed fusion, it was not until the age of 17 years that this was the case in boys. Instances of non-fusion were found at the age of 18 in both sexes.

SESAMOID BONES OF HALLUX

These are usually present beneath the head of the first metatarsal bone on the plantar aspect. The medial sesamoid is frequently split into two by a transverse fissure as though it were fractured. Occasionally the lateral sesamoid is similarly split. These ossicles were found at the age of 13 years and 4 months in a girl and 14 in boys. Borovansky and Hnevkovsky found these present in a boy aged between $11\frac{1}{2}$ and $12\frac{1}{2}$ years.

SESAMOID BONE OF FIFTH METATARSAL

The only instance of this was seen on both sides in a woman aged 21 years and 10 months.

EPIPHYSES FOR SECOND, THIRD, FOURTH AND FIFTH METATARSAL BONES

Age	Instances in girls				Instances in boys				Epiphyses in girls				Epiphyses in boys			
2	6	6	6	6	3	1	3	3	2	2	0	0	0	0	0	0
3	3	3	3	3	1	1	1	1	3	3	1	1	0	0	0	0
4	1	1	1	1	3	3	3	3	1	1	1	1	3	3	2	1
14	1	1	1	1	7	7	6	6	0	0	0	0	7	7	6	6
15	5	5	5	5	5	5	5	5	0	0	0	0	3	3	3	3
16	7	7	7	6	11	12	11	8	1	3	1	1	9	10	9	6
17	4	3	3	3	13	13	16	15	0	0	0	0	1	1	3	3
18	5	5	5	5	8	8	7	7	1	1	1	1	0	0	1	1

In a girl aged 2 years and 6 months centres were present on both sides for the heads of the second and third metatarsal bones, but had not yet appeared for the fourth and fifth. In a female aged 3 years and 11 months, centres for all five metatarsals were present. In a boy aged 4 those for the first, second, third and fourth metatarsals were present, but that for the fifth had not yet appeared. In another boy aged 4 years and 6 months on the right side, centres were present for all five metatarsals, but on the left, although present for the first, second and third, were absent for the fourth and fifth. In a girl aged 2 years and 7 months, and in a boy aged 2 years and 6 months, although

centres were present for the first, epiphyses were absent for all the other metatarsal bones.

The youngest subjects in whom the epiphyses were found fused in all four outer metatarsal bones were a girl aged 14 and a boy aged 15. In a male aged 17 years centres were present in all five metatarsal bones. They were likewise present in a female aged 18. In a male of the same age they were absent in the case of the second and third metatarsal bones although present for the fourth and fifth. Fusion was complete in the majority of girls at the age of 15 and of boys at 17 years of age.

EPIPHYSIS AT BASE OF FIFTH METATARSAL BONE

Age	Instances in girls	Instances in boys	Epiphyses in girls	Epiphyses in boys
12	2	3	1	0
13	8	1	2	0
14	1	9	0	5

Sometimes an epiphysis is seen at the base of the fifth metatarsal bone. When this fails to unite with the shaft, it has been described as the os vesalii, which, according to Woollard, has only been recorded four times in roentgenographic pictures. The youngest female with such an epiphysis was aged 12, the youngest male 14, but instances were noted at the age of 17 in subjects of unknown sex. Its maximum incidence in males at least appears to be at the age of 14 when it was present in 5 of 9 instances. Altogether it occurred 11 times in 70 subjects between the ages of 12 and 17. It is evidently not constantly present. Borovansky and Hnevkovsky noted a centre in a boy aged 11 years and 7 months.

PROXIMAL PHALANX OF HALLUX

Age	Instances in girls	Instances in boys	Epiphyses in girls	Epiphyses in boys
2	5	3	4	1
14	1	5	0	5
15	5	5	0	3
16	6	13	1	11
17	3	15	0	3
18	5	7	1	0

The epiphysis at the base of the phalanx was found in a girl and a boy, each at the age of 2 years and 6 months. In a girl aged 2 years and 4 months it was absent although present in the other phalanges of the row, whilst it was absent in all five proximal phalanges in a boy aged 2 years and 6 months.

The youngest subjects in whom this epiphysis was found fused were a girl aged 14 and a boy aged 15. Fusion had taken place in the majority of girls at the age of 14 and of boys at 17 years of age. Non-fusion was present in a male aged 17 (although fusion was complete in all the other proximal phalanges) and in a female aged 18.

PROXIMAL PHALANGES OF SECOND, THIRD, FOURTH AND FIFTH TOES

Age	Instances in girls				Instances in boys				Epiphyses in girls				Epiphyses in boys			
2	5	5	5	4	3	3	3	3	4	4	4	3	2	2	2	2
14	1	1	1	1	5	5	5	6	0	0	0	0	5	5	5	6
15	5	5	4	4	5	5	5	5	0	0	0	0	3	3	3	3
16	6	6	6	7	11	12	11	10	0	0	0	1	9	10	9	7
17	4	3	3	3	14	14	14	14	0	0	0	0	2	1	1	2
18	5	5	6	6	8	7	7	7	1	1	1	1	0	0	0	1

The epiphyses at the bases of the proximal phalanges were found in a girl aged 2 years and 4 months and in a boy aged 3 years and 2 months. In a boy aged 2 years and 6 months, and in a girl aged 2 years and 7 months, it had not yet appeared in any of the toes.

The youngest subjects in whom these were found fused with the shafts were a girl aged 14 and a boy 15 years of age. As with the metatarsals, the centres were fused in the majority of girls at the age of 14 and of boys at 17 years of age. In a boy of 17 non-fusion was present in all four digits. This was likewise the case in a girl aged 18. In a male aged 18, although fusion was present in the case of the second, third, and fourth toes, that for the little toe was still ununited.

MIDDLE ROW OF PHALANGES

As the various epiphyses of the middle row of phalanges develop at different periods, these will be described in separate groups.

MIDDLE PHALANGES OF SECOND TOE

Age	Instances in girls	Instances in boys	Epiphyses in girls	Epiphyses in boys
2	3	1	1	0
3	3	1	2	1
4	1	2	1	2
5	0	3	0	2
6	1	0	1	0
7	1	2	1	0
8	0	4	0	2
12	1	1	0	1
13	5	2	3	2
14	0	5	0	5
15	4	4	0	1
16	6	9	0	6
17	2	10	0	0
18	2	7	1	0

Earliest centres were found in a girl aged 2 years and 4 months where it was present in the whole row, and in a boy aged 3, where it was also present in the third, but absent in the fourth and fifth toes. It was not present in a girl aged 3, although present in the other phalanges of the row, whilst in a boy aged 8 years and 7 months it was not present in any of the middle phalanges. It was present in the majority of girls at the age of 3 and of boys at the age of 4.

MIDDLE PHALANGES OF THIRD AND FOURTH TOES

Age	Instances in girls	Instances in boys	Epiphyses in girls	Epiphyses in boys
2	2 3	1 1	1 1	0 0
3	3 3	1 1	3 3	1 0
4	1 1	2 2	1 1	0 0
5	0 0	3 4	0 0	2 3
6	1 1	1 0	0 0	1 0
7	1 1	2 2	0 0	0 0
8	0 0	4 4	0 0	2 2
9	0 0	0 0	0 0	0 0
10	0 0	2 3	0 0	1 1
11	0 1	1 1	0 0	1 0
12	2 1	1 0	0 0	1 0
13	5 4	2 2	1 0	0 0
14	0 0	5 3	0 0	2 0
15	4 2	4 4	0 0	1 0
16	6 6	9 7	0 0	3 1
17	2 2	11 10	0 0	0 0
18	3 4	5 6	1 0	0 0

These being vestigial phalanges, the development of their epiphyses is quite different to the others. They were both present in a girl aged 2 years and 4 months. In a boy aged 3 that for the third toe was present although absent for the fourth toe. In a boy aged 5 years and 2 months they were present in each case on both sides. Their presence was noted at various ages right up to adult life. They appeared to be present in the majority of females at the age of 3 and of males at the age of 5.

The oldest subjects in whom these were present was a male aged 16 and a female aged 18, where it was present in the third, but absent in the fourth toe. The absence of these epiphyses may be noted in one of the three following circumstances: (*a*) stage before appearance of epiphysis, (*b*) non-development of epiphyseal centre, and (*c*) fusion of epiphysis with diaphysis, but which of these is present in each particular case is not always evident. Of 19 and 16 instances respectively in girls aged 5 to 16 inclusive, not one epiphysis was present for the fourth, and only one for the third metatarsal (a girl aged 13 years and 7 months, where it was present on the right but not on the left side), although there were 13 and 7 epiphyses respectively in 34 and 30 instances in boys at these ages, suggesting that in females these phalanges are more vestigial than in the male.

MIDDLE PHALANX OF LITTLE TOE

Of 99 instances, including 30 females and 58 males aged 2 to 18, this epiphysis was found 4 times only, including 2 girls aged 2 years and 4 months and 3 years respectively, and a boy aged 12 years and 1 month. It is the exception rather than the rule for this epiphysis to be present at any age.

DISTAL PHALANX OF HALLUX

This epiphysis was present in a girl aged 2 years and 4 months and in a boy aged 1 year and 9 months.

Age	Instances in girls	Instances in boys	Epiphyses in girls	Epiphyses in boys
13	5	2	3	2
14	0	6	0	6
15	5	5	0	3
16	6	11	0	8
17	4	11	0	0
18	4	6	1	0

Fusion was present in a girl aged 13 years and 7 months on both sides and in a boy aged 15. In the majority of girls aged 15 and of boys aged 17 fusion was complete. Union had not yet occurred on either side in a boy aged 16 years and 6 months, nor was it fused in a girl of 18.

DISTAL PHALANGES OF SECOND, THIRD AND FOURTH TOES

The youngest subject where these have appeared in the case of the second and third toes was aged 3 (sex unknown). In a girl aged 3 years and 11 months those for the third and fourth toes were present. They were likewise noted in a boy aged 5, whilst in a girl aged 6 they were present for the second and fourth toes. It was absent in all these digits in a girl aged 3 and a boy aged 8.

Age	Instances in girls	Instances in boys	Epiphyses in girls	Epiphyses in boys
13	3 3 4	1 1 2	1 1 2	1 1 2
14	0 0 0	4 4 3	0 0 0	4 4 3
15	2 3 3	3 4 3	0 0 0	0 1 0
16	5 6 5	6 6 7	0 0 0	2 2 2
17	1 1 2	5 4 5	0 0 0	0 0 0
18	4 4 5	5 3 4	1 1 1	0 0 0

The earliest to fuse were in a girl aged 13 years and 9 months in each case on both sides, and in boys aged 15. The majority were fused in girls at the age of 13 and in boys at 15. Instances of non-fusion in the case of each digit were found in males at the age of 16 and in a female at 18.

DISTAL PHALANX OF LITTLE TOE

Age	Instances in girls	Instances in boys	Epiphyses in girls	Epiphyses in boys
3	2	1	1	1
4	0	1	0	0
5	0	3	0	1
6	0	1	0	0
7	1	2	1	2
8	0	2	0	1
10	0	3	0	2
11	2	2	0	0
13	4	2	1	0
14	0	3	0	0
15	2	5	0	0
16	6	6	0	1

The earliest centres to appear in each sex were aged 3. The oldest girl with an epiphysis was aged 13 years and 8 months and the oldest boy 16.

CHRONOLOGICAL ORDER OF APPEARANCE AND FUSION OF EPIPHYSES

Before birth:		
Both sexes	Appearance	Head of humerus, distal femur, proximal tibia, calcaneum, talus
Female	,,	Cuboid
During first year:		
Both sexes	Appearance	Hamate, capitate, head of femur, third cuneiform
Female	,,	Capitulum, distal radius, distal tibia, distal fibula
Male	,,	Cuboid
During second year:		
Both sexes	Appearance	Proximal phalanges of inner four fingers
Female	,,	First metacarpal, distal phalanges of thumb, middle and ring fingers, tarsal navicular, first and second cuneiforms
Male	,,	Capitulum, distal epiphysis of radius, distal fibula
At age of 2:		
Both sexes	Appearance	Inner four metacarpals, first metatarsal, proximal phalanges of toes, distal phalanx of hallux
Female	,,	Proximal phalanx of thumb, middle row of phalanges of fingers
Male	,,	First metacarpal, distal phalanx of thumb, and distal phalanx of index, first cuneiform
At age of 3:		
Female	Appearance	Patella, proximal fibula, second metatarsal, third metatarsal, middle phalanges of second, third and fourth toes, distal phalanges of third and fourth toes
Male	Appearance	Triquetrum, proximal phalanx of thumb, middle phalanges of middle and ring fingers, tarsal navicular, second cuneiform
At the age of 4:		
Both sexes	Appearance	Fourth metatarsal
Female	,,	Head of radius, fifth metatarsal
	Fusion	Greater tubercle to head of humerus
Male	Appearance	Lunate, middle phalanges of index and little fingers, distal phalanges of middle and ring fingers, second metatarsal, third metatarsal, middle phalanx of second toe
At the age of 5:		
Both sexes	Appearance	Navicular (carpal), multangulum majus, greater trochanter, distal phalanx of second toe
Female	,,	Medial epicondyle, distal ulna, lunate, triquetrum, multangulum minus, distal phalanx of index
Male	,,	Head of radius, distal phalanx of little finger, patella, proximal fibula, fifth metatarsal, middle phalanges of third and fourth toes, distal phalanges of third and fourth toes
	Fusion	Greater tubercle to head of humerus
At the age of 6:		
Male	Appearance	Medial epicondyle, distal ulna, multangulum minus
At the age of 7:		
Female	Appearance	Distal phalanx of little finger
	Fusion	Rami of ischium and pubis
At the age of 8:		
Both sexes	Appearance	Apophysis of calcaneus
Female	,,	Olecranon
At the age of 9:		
Female	Appearance	Trochlea, pisiform
Male	Fusion	Rami of ischium and pubis
At the age of 10:		
Male	Appearance	Trochlea, olecranon
At the age of 11:		
Female	Appearance	Lateral epicondyle
Male	,,	Pisiform

At the age of 12:		
Male	Appearance	Lateral epicondyle
At the age of 13:		
Female	Appearance	Proximal sesamoid of thumb
	Fusion	Lower conjoint epiphysis of humerus, distal phalanx of thumb, bodies ilium, ischium and pubis
Male	,,	Capitulum to trochlea and lateral epicondyle
At the age of 14:		
Female	Appearance	Acromion, iliac crest, lesser trochanter
	Fusion	Olecranon, upper radius, proximal phalanx of ring finger, distal phalanx of thumb, head of femur, greater trochanter, distal tibia and fibula, apophysis calcaneus, first metatarsal, proximal phalanges of toes
Male	Appearance	Proximal sesamoid of thumb, base of fifth metatarsal
At the age of 15:		
Both sexes	Appearance	Sesamoid of little finger
	Fusion	Distal phalanges of second, third and fourth toes
Female	Appearance	Sesamoid of index and little fingers
	Fusion	Medial epicondyle, first metacarpal, proximal phalanx of thumb, distal phalanges of inner four fingers, proximal tibia, outer four metatarsals, middle phalanx of second toe, distal phalanges of inner four toes
Male	Appearance	Acromion
	Fusion	Ilium, ischium and pubis
At the age of 16:		
Female	Appearance	Distal sesamoid of thumb, tuber ischii
	Fusion	Inner four metacarpals, proximal phalanges of index, middle and little fingers, middle phalanges of fingers
Male	,,	Lower conjoint epiphysis of humerus, medial epicondyle, olecranon, head of radius, distal phalanx of middle finger, apophysis of calcaneus
At the age of 17:		
Both sexes	Fusion	Acromion
Female	,,	Upper conjoint epiphysis of humerus, distal ulna, distal femur, proximal fibula
Male	Appearance	Distal sesamoid of thumb
	Fusion	First metacarpal, proximal phalanges of thumb and ring finger, middle phalanges, index, middle and ring fingers, distal phalanges of thumb, index, ring and little fingers, head of femur, greater trochanter, distal tibia and fibula, metatarsals, proximal phalanges of toes, middle phalanx of second toe, distal phalanx of hallux
At the age of 18:		
Female	Fusion	Distal radius
Male	,,	Inner four metacarpals, proximal phalanges of index, middle and little fingers, middle phalanges of little finger, proximal tibia
At the age of 19:		
Male	Appearance	Sesamoid of index, tuber ischii
	Fusion	Upper conjoint epiphysis of humerus, distal radius and ulna, distal femur, proximal fibula
At the age of 20:		
Both sexes	Fusion	Iliac crest
Male	,,	Tuber ischii
At the age of 21:		
Both sexes	Appearance	Clavicle
Female	Fusion	Tuber ischii
At the age of 22:		
Both sexes	Fusion	Clavicle

Table of Epiphyseal Appearances and Fusions

The following table takes into account only the instances noted by the author and the various authorities quoted. (*a*) Earliest appearance of centres in each sex. (*b*) Age at which majority of centres appear in each sex. (*c*) Oldest subjects in which centres have not yet appeared. (*d*) Earliest age at which fusion has occurred. (*e*) Age at which majority of epiphyses have fused. (*f*) Oldest subjects in which fusion has not yet taken place. The figures give the ages in years and months [years only in columns (*b*) and (*e*)]. B.B. denotes before birth.

	(*a*)		(*b*)		(*c*)		(*d*)		(*e*)		(*f*)	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Clavicle	11	12	21	21	—	—	—	—	22	22	26 11	25
Inferior angle of scapula	17	—	—	—	—	—	—	—	—	—	—	—
Base of coracoid process	4 6	—	—	—	7 6	10 3	—	—	—	—	—	—
Angle of coracoid process	10 2	14	—	—	—	—	—	—	—	—	16	19
Tip of coracoid process	—	14 7	—	—	—	16	—	—	—	—	—	—
Distal epiphysis of acromion	13 10	14 11	14	15	—	—	—	—	17	17	16 1	19 2
Head of humerus	B.B.	B.B.	B.B.	B.B.	—	6	—	—	—	—	—	—
Greater tubercle of humerus	1 8	11	—	—	11	3 6	—	—	—	—	—	—
Union greater tubercle and head of humerus	—	—	—	—	—	—	—	—	. 4	5	6	9
Union of conjoint epiphysis	—	—	—	—	—	—	16 8	16	17	19	18	19 2
Lateral epicondyle	8 6	10 7	11	12	16	16	—	—	—	—	—	—
Capitulum	9	11	>1	1	—	6	—	—	—	—	—	—
Trochlea	7	8 9	9	10	16	16	—	—	—	—	—	—
Fusion of distal epiphyses of humerus	—	—	—	—	—	—	10	12	—	13	16	15
Fusion of conjoint epiphysis to shaft	—	—	—	—	—	—	13 4	14 7	13	16	16	16
Do. Sidhom and Derry (Egyptian)	—	—	—	—	—	—	—	—	—	15	—	—
Medial epicondyle	3 10	5 9	5	6	6	7	10	12	14	16	16	17 0
Do. Sidhom and Derry (Egyptian)	—	—	—	—	—	—	—	—	—	16	—	19 3
Do. Galstaun (Hindu girls)	—	—	—	—	—	—	14	—	14	—	16	—
Olecranon epiphysis	6	7	8	10	10	—	13	14	14	16	16 0	17 6
Do. Galstaun (Hindu girls)	—	—	—	—	—	—	14	—	14	—	15	—
Head of radius	3 4	4 3	5	5	6	8	13	14	14	16	16	20
Do. Davies and Parsons	2	—	—	—	—	—	—	—	—	—	—	—
Do. Galstaun (Hindu girls)	—	—	—	—	—	—	14	—	14	—	18	—
Distal epiphysis of radius	9	1	>1	1	—	1 9	16 6	18 5	18	19	20 5	23
Do. Sidhom and Derry (Egyptian)	—	—	—	—	—	—	—	16	—	19	—	—
Do. Galstaun (Hindu girls)	—	—	—	—	—	—	14	—	19	—	—	—

	(a)		(b)		(c)		(d)		(e)		(f)	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Distal epiphysis of ulna	5	5	5	6	7	12	16 6	18 5	17	19	22	23
Do. Sidhom and Derry (Egyptian)	—	—	—	—	—	—	—	15 11	—	18	—	—
Do. Paterson	4	—	—	—	—	—	—	—	—	—	—	—
Do. Galstaun (Hindu girls)	—	—	—	—	—	—	14	—	—	—	—	—
Do. Pryor (U.S.A.)	—	—	—	—	—	—	—	—	16	19	—	—
Styloid process of ulna	—	13 10	—	—	—	—	—	—	—	—	—	—
Do. Borovansky and Hnevkovsky (Prague)	—	5 10	—	—	—	—	—	—	—	—	—	—
Navicular	5	4 6	5	5	5 5	8	—	—	—	—	—	—
Do. Pryor (U.S.A.)	3 6	4 4	4	6	6 4	8 3	—	—	—	—	—	—
Lunate	2 7	1	5	4	3 5	6 11	—	—	—	—	—	—
Do. Pryor (U.S.A.)	—	—	3	5	6 3	—	—	—	—	—	—	—
Triquetrum	1 6	2	5	3	3	4	—	—	—	—	—	—
Do. Pryor (U S.A.)	—	1 9	2	—	—	5 5	—	—	—	—	—	—
Pisiform	8 6	7	9	11	10	14 7	—	—	—	—	—	—
Do. Pryor (U.S.A.)	7 7	—	—	—	10 7	—	—	—	—	—	—	—
Hamate	9	10	>1	>1	—	1 week	—	—	—	—	—	—
Do. Pryor (U.S.A.)	3	7	—	—	7	—	—	—	—	—	—	—
Capitate	9	10	>1	>1	—	1 week	—	—	—	—	—	—
Do. Pryor (U.S.A.)	4 days	2 days	—	—	3	7	—	—	—	—	—	—
Multangulum minus	3 5	4 6	5	6	4	8	—	—	—	—	—	—
Do. Pryor (U.S.A.)	—	—	4	6	6 7	8 3	—	—	—	—	—	—
Multangulum majus	3 5	5	5	5	3 5	8	—	—	—	—	—	—
Do. Pryor (U.S.A.)	—	4 1	—	7	6 7	8 10	—	—	—	—	—	—
First metacarpal	1 2	2 6	1	2	2 5	3	13	14	15	17	15	19 7
Do. Sidhom and Derry (Egyptian)	—	—	—	—	—	—	—	—	—	16	—	—
Do. Galstaun (Hindu girls)	—	—	—	—	—	—	14	—	15	—	—	—
Second metacarpal	1 11	1	1	1	2 5	2	14 9	16	16	18	18	20 7
Do. Davies and Parsons	1 3	—	—	—	—	—	—	—	—	—	—	—
Do. Galstaun (Hindu girls)	—	—	—	—	—	—	14	—	14	—	18	—
Third metacarpal	1 11	1	1	1	2 5	3	15	16	16	18	17	20 7
Do. Davies and Parsons	1 3	—	—	—	—	—	—	—	—	—	—	—
Do. Galstaun (Hindu girls)	—	—	—	—	—	—	14	—	14	—	18	—
Fourth metacarpal	1 10	1	2	2	2 5	3	15	16	16	18	17	19
Fifth metacarpal	1 5	1	2	3	2 5	3	15	16	16	18	17	19
Do. Galstaun	—	—	—	—	—	—	14	—	14	—	18	—
All metacarpals—Palmer	—	—	—	—	—	—	14 5	—	—	—	—	—
Proximal phalanx of thumb	1 11	3 10	1	3	2 5	2 10	13 8	14	15	17	15 6	19 11
Index finger	1 4	1	1	1	—	—	13 8	14	16	18	16	19 7
Middle finger	10	1	>1	>1	—	2	13 8	14	16	18	16	19
Do. Sidhom and Derry (Egyptian)	—	—	—	—	—	—	—	—	—	—	—	19 3

	(a)		(b)		(c)		(d)		(e)		(f)	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Ring finger	10	1	>1	1	—	3	14	14	14	17	16	19
Do. Sidhom and Derry (Egyptian)	—	—	—	—	—	—	—	—	—	—	—	19 3
Little finger	1 10	1	1	1	1 6	3	13	14	16	18	16	19
Do. Sidhom and Derry (Egyptian)	—	—	—	—	—	—	—	—	—	—	—	19 3
Proximal sesamoids of thumb	11 5	14 5	13	14	12	15	—	—	—	—	—	—
Sesamoid of index finger	11 6	14	15	19	23	27	—	—	—	—	—	—
Middle finger	13 10	14 0	—	—	—	—	—	—	—	—	—	—
Ring finger	—	21	—	—	—	—	—	—	—	—	—	—
Little finger	13 10	14	15	18	23	27	—	—	—	—	—	—
Distal sesamoid of thumb	16 3	15	16	16	23	27	—	—	—	—	—	—
Middle phalanx of index finger	1 11	4	2	4	2 5	2	13 8	14	16	17	15	19
Middle finger	1 11	3	1	3	2 5	2	15	15 11	16	17	16	19
Ring finger	1 11	3	1	3	2 5	2 6	15	14	16	17	16	19
Little finger	2	4	2	4	3 5	2 6	15	14	16	17	15	19
Distal phalanx of thumb	10	1	1	2	1 10	2	13	14	13	17	15	19 7
Do. Sidhom and Derry (Egyptian)	—	—	—	—	—	—	—	—	—	15	—	—
Index finger	5	2	5	2	1 11	2	14 9	14	15	17	15	17
Middle finger	1 11	4	1	4	1 2	2	14	14	15	16	15	17
Ring finger	1 11	4	1	4	2 5	3 6	14	14	15	17	16	17
Little finger	4	5	7	5	1 11	2	15 6	14	15	17	15	17
Union of ilium, ischium and pubis	—	—	—	—	—	—	10 6	13	13	15	16 10	16 3
Union of rami of ischium and pubis	—	—	—	—	—	—	3 11	5 9	7	9	11	10
Ischic-pubic union (Davies and Parsons)	—	—	—	—	—	—	—	3	—	—	—	—
Iliac crest	14	15	14	16	14	—	17	—	20	20	21	21 7
Tuber ischii	13 5	13	16	19	—	—	—	—	21	20	24	21
Anterior superior iliac spine	13 5	—	—	—	17	—	—	—	—	—	—	—
Head of femur	10	6	>1	>1	—	9	14	14	14	17	16 10	20 2
Do. Borovansky and Hnevkovsky (Prague)	—	3 weeks	—	—	—	—	—	—	—	—	—	—
Do. Davies and Parsons	6	—	—	—	—	—	—	—	—	—	—	—
Greater trochanter	2	3 11	5	5	4	6	14	15	14	17	16 10	17
Do. Borovansky and Hnevkovsky (Prague)	—	3 5	—	—	—	—	—	—	—	—	—	—
Lesser trochanter	9	10 9	14	—	—	—	—	—	—	—	16 10	17
Distal epiphysis of femur	B.B.	B.B.	B.B.	B.B.	—	—	14	16	17	19	19	19
Do. Pryor (U.S.A.)	P.B.*	—	—	—	—	3 days	—	—	—	—	—	—
Patella	2 6	3 11	3	5	3 0	8	—	—	—	—	—	—
Do. Borovansky and Hnevkovsky (Prague)	—	3 7	—	—	—	—	—	—	—	—	—	—
Fabella	17	16 5	—	—	—	—	—	—	—	—	—	—

* Premature birth. 2 days after 8 months.

	(a)		(b)		(c)		(d)		(e)		(f)	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Proximal epiphysis of tibia	B.B.	B.B.	B.B.	B.B.	—	—	14	16	15	18	19	19
Do. Pryor (U.S.A.)	P.B.*	—	—	—	25 days	—	—	—	—	—	—	—
Proximal epiphysis of fibula	3 11	3 4	3	5	4	5	14	16	17	19	18	19
Do. Paterson	2	—	—	—	—	—	—	—	—	—	—	—
Distal epiphysis of tibia	7	9	>1	—	—	—	13	15	14	17	16 4	18
Do. Borovansky and Hnevkovsky (Prague)	—	3	—	—	—	—	—	—	—	—	—	—
Distal epiphysis of fibula	11	9	>1	1	7	1 8	14	15	14	17	16 4	18
Apophysis of calcaneus	7	7 5	8	8	7 9	8 7	12 10	15	14	16	16	18
Do. Borovansky and Hnevkovsky (Prague)	—	6 2	—	—	—	—	—	—	—	—	—	—
Cuboid—Pryor (U.S.A.)	P.B.*	B.B.	B.B.	—	25 days	13 days	—	—	—	—	—	—
Tarsal navicular	1 3	2 6	1	3	3	5	—	—	—	—	—	—
First cuneiform	1 8	2 6	1	2	11	2 2	—	—	—	—	—	—
Do. Davies and Parsons	1 0	—	—	—	—	—	—	—	—	—	—	—
Second cuneiform	1 8	2	1	3	2 6	2	—	—	—	—	—	—
First metatarsal	2 6	2 6	2	2	2 7	3 6	14	15	14	17	18	18
Do Davies and Parsons	10	—	—	—	—	—	—	—	—	—	—	—
Sesamoids of hallux	13 4	13	—	—	11	8	—	—	—	—	—	—
Second metatarsal	2 6	4 6	3	4	2 7	3	14	15	15	17	18	17
Third metatarsal	2 6	4 6	3	4	2 7	3	14	15	15	17	18	17
Fourth metatarsal	3 11	4 6	4	4	3	4 6	14	15	15	17	18	18
Fifth metatarsal (head)	3 11	4 6	4	5	3	4 6	14	15	15	17	18	18
Fifth metatarsal (base)	12	13	—	14	—	—	—	—	—	—	13 7	16
Do. Borovansky and Hnevkovsky (Prague)	—	11 7	—	—	—	—	—	—	—	—	—	—
Proximal phalanx of hallux	2 6	2 6	2	2	2 4	2 6	14	15	14	17	18	17
Do. Davies and Parsons	10	—	—	—	—	—	—	—	—	—	—	—
Proximal phalanx of second toe	2 4	2 2	2	2	2 7	2 6	14	15	14	17	18	17
Third toe	2 4	2 2	2	2	2 7	2 6	14	15	14	17	18	17
Fourth toe	2 4	2 2	2	2	2 7	2 6	14	15	14	17	18	17
Fifth toe	2 4	2 2	2	2	2 7	2 6	14	15	14	17	18	18
Middle phalanx of second toe	2 4	3	3	4	3	8 7	12	15	15	17	18	16
Third toe	2 4	3	3	5	—	—	13 7	—	—	—	18	16
Fourth toe	2 4	5 2	3	5	—	—	13 7	—	—	—	4	16
Fifth toe	2 4	12 1	—	—	—	—	13 7	—	—	—	—	—
Distal phalanx of hallux	2 7	1 9	2	2	—	2 6	13 7	15	15	17	18	16 6
Second toe	6	5	5	5	3	8	13 9	15	15	15	18	16
Third toe	3 11	5	3	5	3	8	13 9	15	15	15	18	16
Fourth toe	3 11	5	3	5	3	8	13 9	15	15	15	18	16
Fifth toe	3	3	—	—	—	—	—	—	—	—	13 8	16

* Premature birth. 2 days after 8 months.

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EXPLANATION OF PLATES I AND II

PLATE I (figs. 1–5).

Fig. 1. Boy, age 14 years 7 months. Demonstrating (*a*) epiphyses at angle of coracoid, (*b*) tip of coracoid, (*c*) acromion process, (*d*) fused head and greater tubercle of humerus.

Fig. 2. Male, age 6 years and 11 months. Multangulum majus well marked on left, but completely absent on the right; lunate just appeared on right but no trace on left.

Fig. 3. Same hands as fig. 4. Note two centres for lunate on left side, one dorsal to other.

Fig. 4. Female, age 6. Note two centres for lunate on left side.

Fig. 5. Sesamoids at heads of all metacarpals. Two sesamoids over fifth.

PLATE II (figs. 6–10).

Fig. 6. Age 21. Sesamoids at heads of first, second, third and fifth metacarpals. Large sesamoid over *centre* of third metacarpal.

Fig. 7. Male, age 18. Epiphyses along perineal margin at apex of perineal triangle.

Fig. 8. Female, age 14. Epiphysis for anterior superior iliac spine.

Fig. 9. Female, age 17. Epiphysis for anterior superior iliac spine.

Fig. 10. Female, aged 2 years and 3 months. Two centres present for first cuneiform.

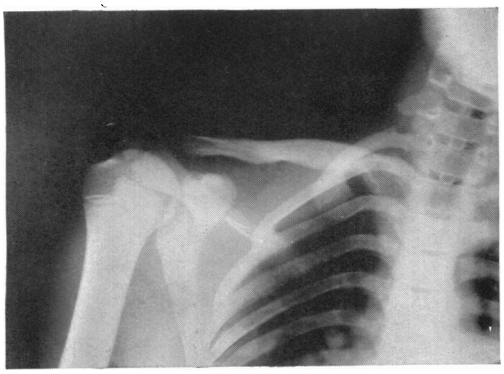

Fig. 1.

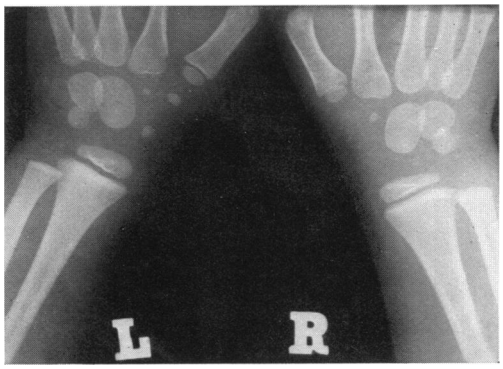

Fig. 2.

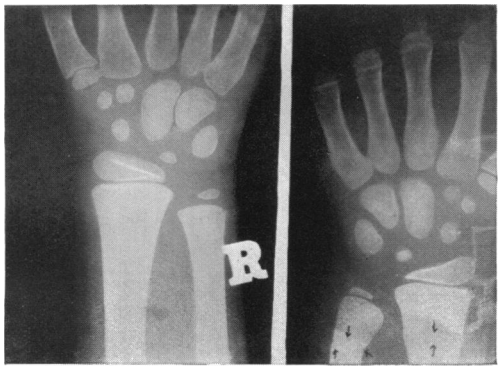

Fig. 3.

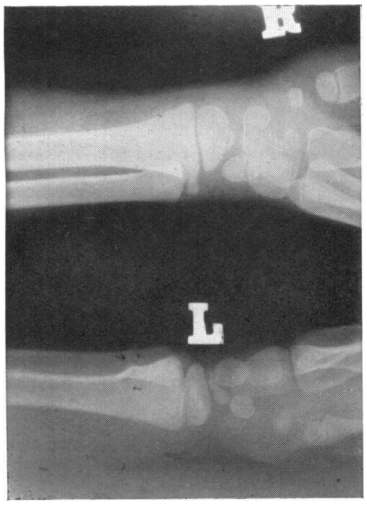

Fig. 4.

Fig. 5.

Fig. 6.

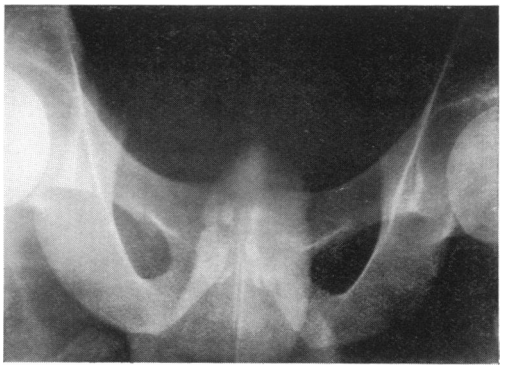

Fig. 7.

Fig. 8.

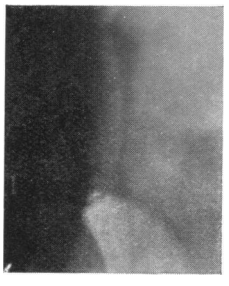

Fig. 9.

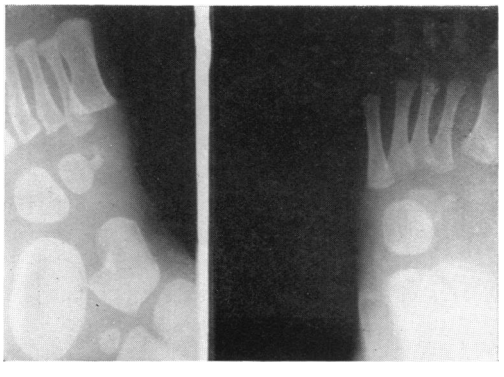

Fig. 10.